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THE ENGINEERS' DIGEST

REVIEW OF ENGINEERING PROGRESS ABROAD

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A New Automatic Welder for Carbon Welding.
Welding of Thick Aluminium Sheets.
Horizontal Diesel Engines for Motor Coaches.
Development of Flotilla Leaders since 1914.
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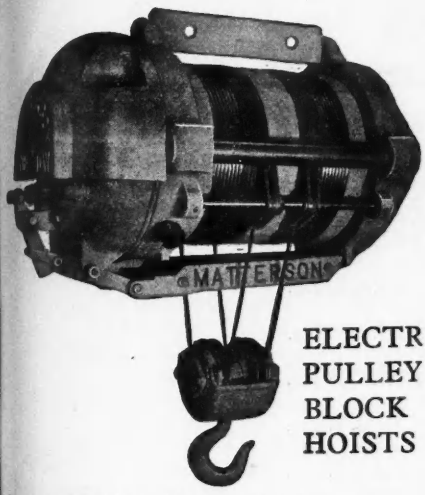

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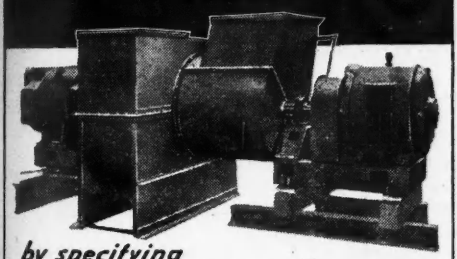

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A NEW AUTOMATIC WELDER FOR CARBON ARC WELDING

By L. PROELS. (From Siemens' *Zeitschrift*, Vol. 21, January, 1941, pp. 10-12).

THE new Siemens carbon arc welder, Type LAK 101, is schematically illustrated in Fig. 1. Two D.c. shunt motors, a and b, provide the necessary feed to the carbon electrode holder (e) through a differential gear (c) and a gear wheel (d). Motor (a) is connected into the electric circuit of the arc, and its speed, therefore, varies with the voltage across the arc. Motor (b) is connected to a constant voltage D.c. circuit, and is running at a constant speed which can be adjusted by a shunt regulator.

The position of the carbon rod and consequently the arc pressure will depend on the relative speed of motors (a and b) since both are acting on the differential gear (c). If the speed of the two motors is identical, the shaft connecting (c) with the gear (d) remains stationary. If for instance (a) has a greater speed than (b), owing to an increase in the arc voltage due to the burning down of the carbon rod, the wheel (d) is rotating in such a direction as to advance the carbon rod. The reverse action takes place if the speed of motor (a) falls below that of motor (b). The arc pressure can be easily kept constant at say 30 volts by adjusting the speed of motor (b) so that it has a speed equal to that of motor (a) when the potential difference across the terminals of the latter is 30 volts.

As is well known a magnetic flux is essential to obtain a constant arc when using a carbon arc welder. In the new Siemens device this is provided by coils (g) fed from a separate D.c. generator. The advantage attached to this method is an almost stepless regulation of the magnetic field even during operation, and the direction of the magnetic field can be reversed by means of a reversing switch.

The coil (g) consists of two sets of windings, one of which can be cut out, in the other the current can be regulated. Thus, any desired magnetic field intensity can be obtained.

All the cooling water ducts are arranged in the interior of the welder head (Fig. 2). All the regulators are fitted into a casing to which the motors are flange mounted.

The conical carbon rod holder (e) (Fig. 2) consists of two concentric tubes, the outer of which is geared and enables easy fixture and adjustment of the welding carbon rod. The current to the electrode fixed in a water cooled nozzle, passes through a copper cylinder tightly enclosing

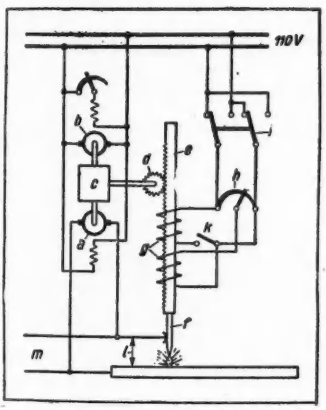


Fig. 1

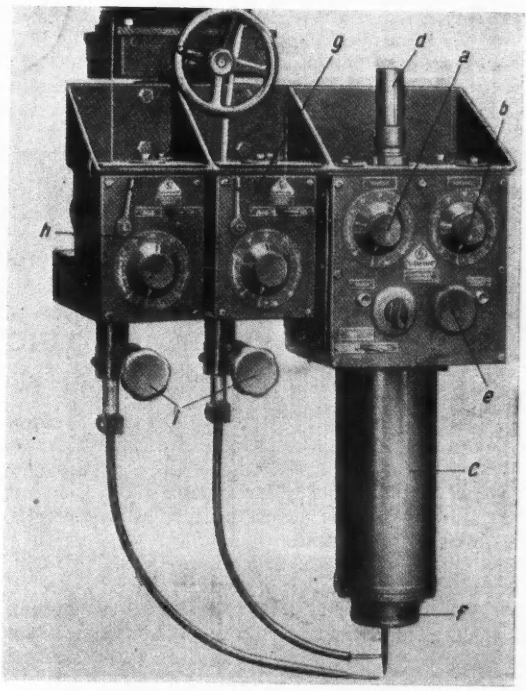


Fig. 2

the carbon rod. Effective cooling of the carbon rod is obtained in this manner and the consumption is reduced to a minimum.

Since carbon arc welders work with longer arcs than metal arc welders, oxygen and nitrogen from the surrounding air could penetrate unhindered into the melting bath. This would deteriorate the quality of the weld. This difficulty is overcome by the following arrangement. A flange mounted motor (g in Fig. 2) drives a geared wheel against which a paper strip is pressed by means of an eccentric roller bearing mounted on a shaft. The paper strip serving as a deoxydising medium is thus fed through a tubing to the glowing carbon where it burns away. This results in a reducing atmosphere, preventing the penetration of oxygen and nitrogen of the air

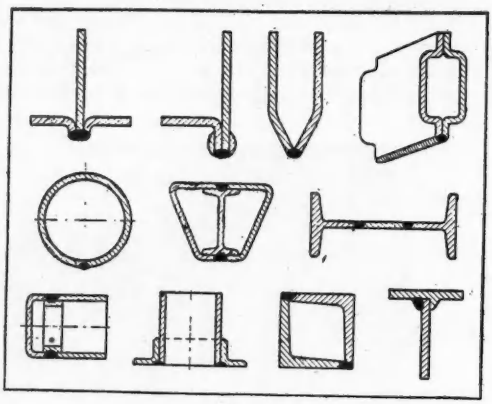


Fig. 3

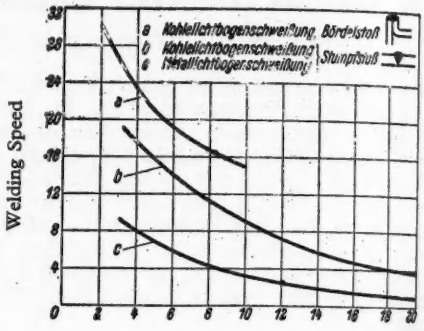


Fig. 4

Sheet thickness in mm.

(a) Carbon arc welding, Butt welding ; (b) Carbon arc welding ; (c) Metallic arc welding.

into the bath. The piping can be adjusted and turned away by the adjusting screw (i).

Another similar feeding device is arranged for (h in Fig. 2) to feed material to the seam which is lost due to burning and evaporation and through the air gaps at the welding. Instead of a paper cordel a thin wire made of suitable material is fed to the arc. The quantity of material fed to it can be regulated between wide limits, by changing the speed of the motor or the thickness of the wire.

Carbon arc welding is mainly used for straight and rounded butt welds, welding of corners and for overlapping welding. Some of the principal jointings obtained with this type of welder are shown in Fig. 3. In Fig. 4 the welding speed relative to work thickness is illustrated graphically.

WELDING OF THICK ALUMINIUM SHEETS

By H. Buchholz. (From *Zeitschrift des VDI*, Vol. 85, April 10th, 1941, pp. 433-437).

The investigation of the strength characteristics of welded aluminium sheets of greater thickness is justified by the fact that aluminium is employed not only by virtue of its resistance to corrosion but also for pressure vessels because of its strength/weight, properties.

The investigations were carried out on 25 mm. thick, heat treated aluminium sheet metal of 99.5% purity. Electrodes of pure aluminium, aluminium with 5% silicon, and aluminium with 0.2% titanium were used. Gas flame welding was carried out with Firinit as flux.

Gas flame welding : for light metals up to 1.5 mm. sheet thickness the welding is effected without adding aluminium to the seam. Sheets between 1.5 and 3 mm. thickness are butt welded. V-seam welding is used for sheet thickness of between 3 and 12 mm., and X-seam welding is used for still greater sheet thickness. Gas flame welding has many advantages and should be employed for non-ferrous metals whenever possible. The protection of the welded seam by the flux and flame-gases ensures a clean welded seam and better use of heat for quick welding.

Arc welding: V-seam welding was carried out in a horizontal position. The welding current was 270 amps D.c. 25 mm. thick sheets were welded in four layers, the first layer with an electrode of

8 mm. diam., the others with an electrode of 10 mm. diam. After finishing each layer the seam was cleaned from slag.

X-ray examination: The purpose of this investigation was to detect faults in the welding, gas and slag inclusions. It can be seen from Figs. 1 and 2 that the gas flame welded seams are practically faultless, only a slight amount of oxide and flux inclusion can be detected. The light spots in Fig. 2 are the result of hammering when removing the slag.

Fig. 1

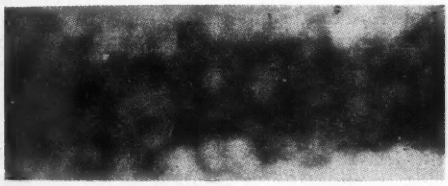


Fig. 2

The arc welded seams show rather more slag inclusion (Figs. 3 and 4). This is due to the cooling of the sheets during slag removal. As this was interrupted from time to time, it was found difficult to remove the slag which cooled very quickly. This defect, however, can be avoided with increasing training and experience of the welder.

Examination of strength and corrosion resistance was carried out in succession. It should be mentioned however at this point, that whereas

Fig. 3

Fig. 4

slag inclusions effected the strength characteristics only slightly, they had a more marked effect on the corrosion resistance of the seam.

Macrostructure of the Welds.

Similarily to other pure metals, aluminium shows a coarse grain texture at the seam. From the edges of the seam the metal grains grow coarser towards the molten part. The coarseness is increased by greater sheet thickness, Figs. 5 to 8. These seams are V-welded. In Fig. 9 an X-seam welding is shown, performed vertically, welded simultaneously from both sides. In spite of greater sheet thickness the seam shows a

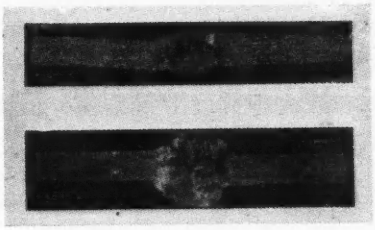


Fig. 5 Gas flame welding; Sheet thickness 5 mm.

Fig. 6 Arc welding; Sheet thickness 5 mm.

Fig. 7. Gas flame welding; Sheet thickness 15 mm.

Fig. 8. Arc welding; Sheet thickness 15 mm.

much finer crystalline structure. This is due to the fact that to reduce the danger of the molten metal flowing away from the weld the amount of molten metal is kept to a minimum, and this limits the growth of the crystals.

V-seam welding of 25 mm. thick sheets in single or double layers shows a coarser structure than the vertically welded X-seams, Figs. 10 and 11. In the neighbourhood of the seam a coarse, overheated and re-crystallised region can be seen. Cold or hot working of the X-seams has little or no effect on the crystalline structure. Quenching of X or V-seams causes an increased coarseness of the structure, since the necessary temperature for fine grain formation is not reached. A finer crystalline structure can be obtained by using electrodes containing titanium or silicon.

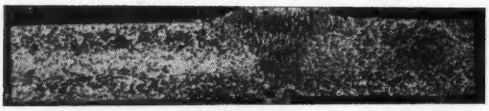


Fig. 9

Fig. 10

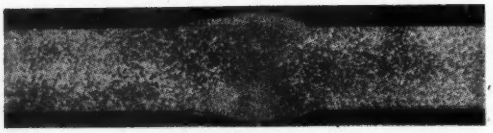


Fig. 11

With arc welding the grain structure is still coarser as can be seen from Fig. 12. Cold working only affects the outer layers to a few mm. depth. An improvement is obtained if the welding is carried out in layers, since this prevents the formation of very coarse structure.

Fig. 12

Examination of Strength Characteristics.

Welded sheets were examined for tension, bending, hardness and test pieces were examined under the microscope. The samples were finished by milling the seams to sheet thickness. The effective length of the sample used for tensile strength examination was 11.3 $V\overline{f}$, where f is the cross sectional area.

The elongation diagram is of the usual shape. The first part of the graph shows identical characteristics for the base material and welded seam. Flowing however, starts earlier in the welded seam (2.5 kg/mm²) than in the base material (4.0 kg/mm²). Fracture, too, takes place earlier in the seam, otherwise the characteristics are similar. Yield point, ultimate strength, percentage elongation and reduction of cross sectional area are somewhat smaller for the welded parts than for the base material. Hot or cold working of the X-seams has no effect on the strength characteristics.

Fracture occurs normally at about 50 or 600 mm. from the centre of the seam, i.e., in the coarse grain region of the transition part. At these points plastic deformation and consequently fracture starts first.

The percentage elongation of the seam and its surrounding is about 12 to 14% compared with 20 to 25% of that of the base material. In Fig. 13 the 0.2% elongation limits were determined over a length of 50 mm. covering the seam region. Plastic deformation started at these parts at about 1.5 to 2.0 kg/mm². The composition of the material has very little effect on this, on the other hand a distinct difference, although unimportant from the practical point of view, results from the different degrees of finishing. The position of the strain limit shows great difference between the seam and the base material. Arc welded thick aluminium sheets behave similarly to gas flame welded ones. The ultimate strength is very nearly that of the base material irrespective of composition and treatment. The ultimate strength of the aluminium base under investigation was 8.4 to 8.6 kg/mm², and that of the welded seam about 7.7 to 8.0 kg/mm².

Bend Tests.

These show more clearly the ductility of the welded portion. As long as the sample did not show considerable surface defects, nearly all samples reached a bending angle of about 180°. Samples which were welded with pure aluminium or titanium alloy electrodes showed greatest elongation, up to about 75%, along the seams. No difference was encountered with gas flame or

arc welded specimens. With silicon alloy electrodes the welded specimen showed greatest ductility in the region near the seam, owing to the greater hardness of the seam material.

Corrosion Tests.

For a quick corroding method a solution of NaCl with addition of hydrogenperoxyde was employed; the NaCl content was 3% and that of H_2O_2 0.1%. After 63 days samples welded with silicon alloy electrodes were excessively corroded.

The other samples showed a corrosion resistance similar to that of the base material. Those with titanium alloy welds showed slightly less resistance to corrosion. It was generally concluded that silicon alloy electrodes are unsuitable for welding by gas flame or electric arc.

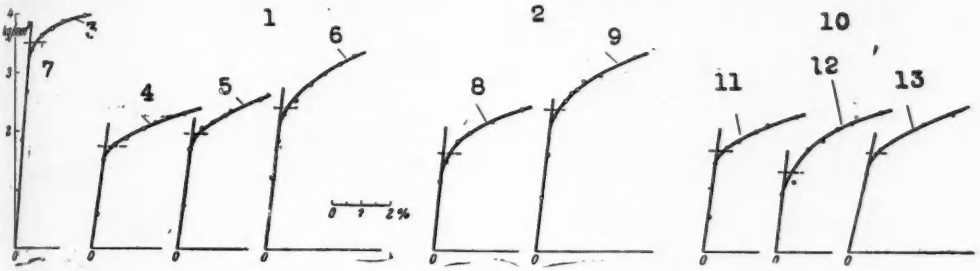


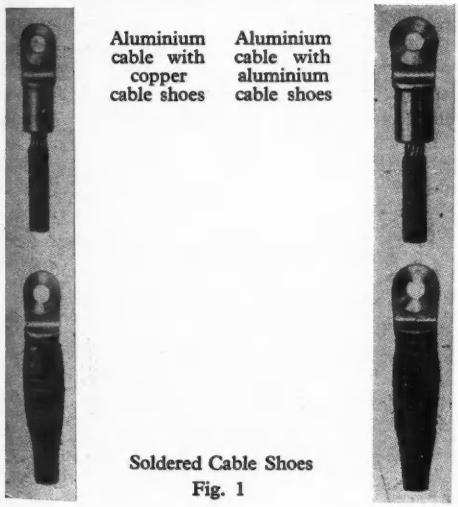
Fig. 13

(1 and 10) Gas flame welded; (2) Arc welded; (3) Sheet metal not treated; (4 and 8) not treated; (5) Warm hammered; (6 and 9) Cold hammered; (7 0.2) Elongation point; (11) Pure aluminium electrode; (12) Titanium alloy electrode; (13) Silicon alloy electrode.

JOINTING OF ALUMINIUM CABLES

By F. OTTEN. (From Siemens' *Zeitschrift*, Vol. 21, January, 1941, pp. 4-10).

THE laying of aluminium cables can be performed in a similar manner to that of copper cables since they have very nearly the same mechanical properties. Jointing of aluminium cables, however requires special considerations.



Soldered Cable Shoes

Fig. 1

The joints of aluminium cables are made either thermolitically, by soldering, welding or casting, or else mechanically by clamping. The thermolitically produced joints are excellent in every respect. Clamping is much inferior, and therefore, should be avoided if possible. There are only two cases where clamping is the only jointing method: when owing to fire danger open flames cannot be used, and the branching of uncut cable.

Great care must be exercised that the aluminium cable should not get into metallic contact with other metals, especially strongly positive metals at places where water or water vapour may penetrate the joint. Otherwise the formation of a thermo-electric couple may cause excessive corrosion. Any metallic jointing set such as socket joint, etc., can be safely used for jointing aluminium cables where the joint is not exposed to dampness. Transition points between the cable and the cable shoe should be protected against moisture by a coating. In some cases it is sufficient to cover the joint with a layer of bitumen-lacquer or grease. Such protection is

also recommended for aluminium cables with aluminium shoes, because the tin-solder may form a thermo-electric couple with the aluminium cable (Fig. 1).

How to Make Joints.

Soldering: This is by far the easiest method to joint aluminium cables. Ordinary soldering tools can be used and with this method aluminium cable can be readily jointed to a copper cable by a copper shoe (Fig. 2).

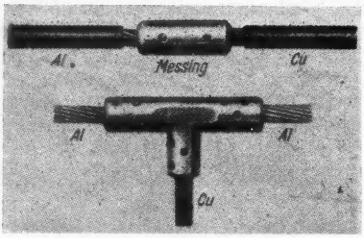


Fig. 2. Soldered joints.

Since aluminium readily oxidises to form an oxide layer on the cable, a method should be employed to prevent the formation of this layer during soldering. This can be achieved chemically by using a suitable flux, but this method is not very satisfactory owing to the fact that it renders the cable porous. A better method is as follows: the wires of the cable are separated, cleaned from the oxide layer by brushing it strongly with a wire brush, and then rubbed with a metallising solder by simultaneously heating it with a blow lamp. The solder used should have a high melting point (about 400° C.), Fig. 3. By this method the oxide-layer is removed and a metallic layer is put on to the cable wires. The single wires are now bent together and brought into the cable shoe. The joint is finished by soldering with tin in the usual manner. Aluminium cables are soldered without using flux.

Welding: To prevent the insulation of the cable from excessive heating, intense local heating should be employed. This can be achieved by using suitable blow lamps. Further, on both sides of the joint cooling plates are fixed to the cable to reduce heat transfer to the insulating material. As a flux Firinit and Autogal are recommended. Three main welding methods are described in the following.

(a) The open V-welding (Fig. 4). The ends of the cable are cut off at an angle, cleaned from the adhering impregnating agent and placed on a half cylinder so that they form a V. Both the

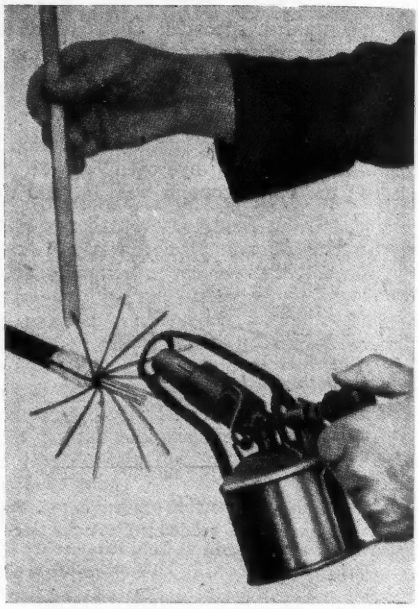


Fig. 3. Metal coating of cable wires.

cable ends and the welding electrode (aluminium) are laid on with the flux. Care should be taken that the welding flame should not be rich in oxygen to prevent burning off of the cable. The joint is then finished as shown in Fig. 4.

(b) Profile welding: The cable ends are prepared as before but the half cylinder is replaced by a cylinder made up from two halves, the top one of which has a hole through it. The cables are indirectly heated by applying the blow lamp to the former (Fig. 5). Fig. 6 shows the welding formerly used for vertical welding.

(c) Electric welding: This is principally butt welding, and can be performed in a very short

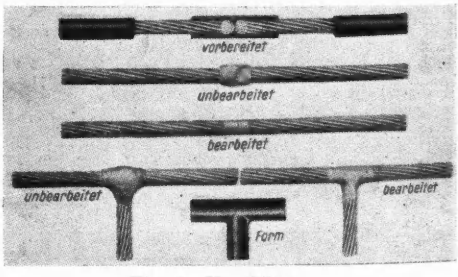


Fig. 4. V-welding.

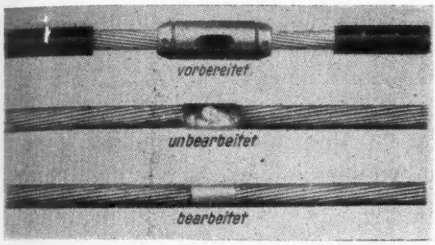


Fig. 5. Profile welding.

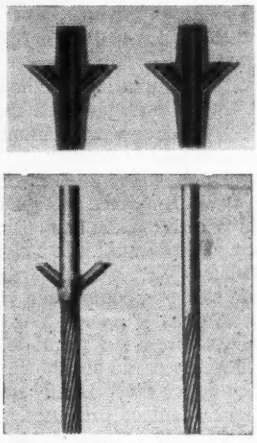


Fig. 6. Vertical profile welding.

time without overheating the insulating material. Because it requires expensive instruments and in some cases a separate generator set, it is not generally used.

Fig. 8. Casting of joint.

Casting: The cable ends are prepared in a similar manner as before and are laid on with flux. In Fig. 7 casting formers for vertical and horizontal jointing are shown. These formers have a wall thickness of only about 1 mm. and the interior is painted with a chilled paint and properly dried before casting. The aluminium required for casting is melted in a chamotte-crucible at about 850° C. and then poured over the former until the latter becomes red hot (Fig. 8). This type of joint is as good as a welded joint.

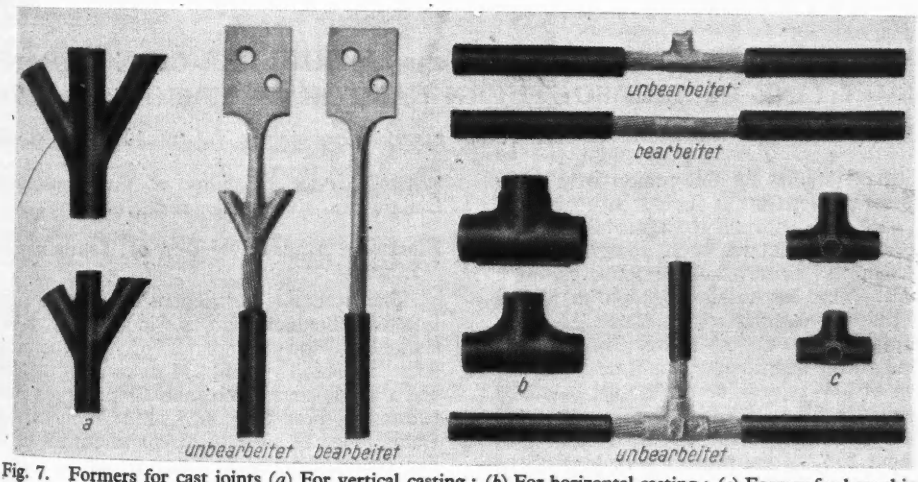


Fig. 7. Formers for cast joints (*a*) For vertical casting; (*b*) For horizontal casting; (*c*) Former for branching.

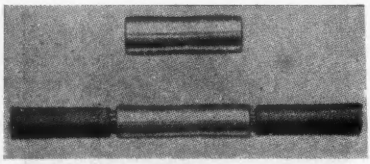


Fig 9. Pressed joint. On top, sleeve.

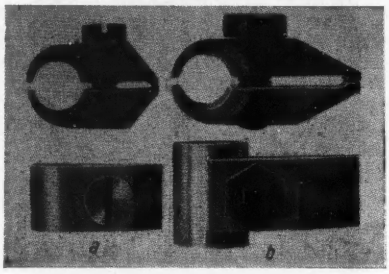


Fig. 10
(a) For copper cable; (b) For aluminium cable.

Since it requires only about 10 to 20 secs. to complete the joint, only a small amount of heat is conveyed to the insulating material if cooling plates are employed.

Clamping: As mentioned before this should be avoided, because the necessary high specific bearing pressure and small current density is very difficult to obtain. Further with multi-wire cables, metallic contact is only made with the outer layers of wires, the inner ones being isolated by the oxide layer. Conditions are much better with overhead cables, since here ample room is available for a suitable joint and the current

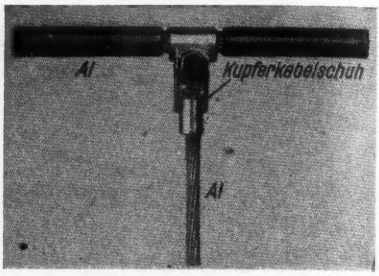


Fig. 11. Finished branch from uncut aluminium cable.

density in the cables is usually about half that of an underground cable.

Two mechanical jointing methods will be described in the following, which can be used when there is fire risk or when a branching of an uncut cable is needed.

The first method is illustrated in Fig. 9. The wire ends are carefully cleaned and spliced. Then they are freed from the oxide film, painted with a contact-paste and introduced into a cleaned fluted aluminium sleeve. With a small hydraulic press the aluminium sleeve is compressed with a pressure of about 25 tons.

For branching from an uncut cable special clamps were developed and are shown in Figs. 10 and 11. They are of exceptionally strong design to enable higher contact pressures. The cross sectional area for both clamps shown in Fig. 10 is 120 mm^2. The clamps are made from brass for elasticity to follow the extensions of the cable. The jointed cable is then fixed in the usual way by means of copper cable shoes.

ENGINEERING FEATURES OF THE 230-kV BOULDER-CHINO TRANSMISSION LINE OF THE SOUTHERN CALIFORNIA EDISON CO., LTD.

By ALEX. A. KRONEBERG and E. M. HUNTER. (From *Electrical Engineering*, Vol. 59, 1940, pp. 982-87.)

PRELIMINARY studies for this project were made on the assumption that it should be a high capacity peak plant with a high degree of reliability of service. But it was soon recognized that the system was already well equipped for peak demands. This led to the decision to fit the power into the existing system of the Southern California Edison Co. as a base load supply. To justify this base load operation it was necessary to keep as low as possible the annual cost of a kWh delivered from Boulder Dam to the company's system. Since the power, 165,000 kW, was about 25% of the present peak load of the system, service reliability of the transmitting facilities was still a major factor.

Electrical Characteristics of Transmission Line.

The economic restrictions dictated a single line from Boulder Dam to Chino, Calif., a substation on the boundaries of the company's subtransmission system, 234 miles from the dam, and a single-circuit line from Chino to the Barre substation, near Stanton, Calif., 26 miles from Chino (Fig. 1). Electrical characteristics of the line are summarized in Table I.

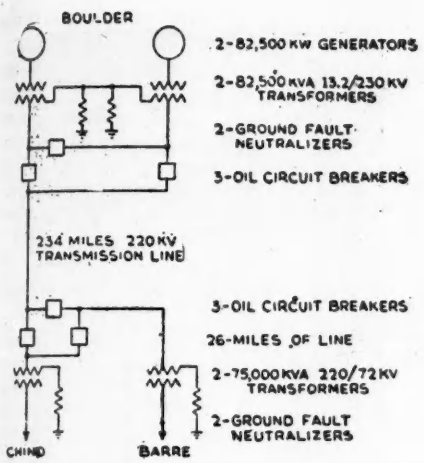


Fig. 1
Schematic single-line diagram of the Boulder-Chino-Barre 230-kV transmission.

TABLE I.

Electrical Design characteristics of Transmission Line.

Steady state power limit	180,000	kW
Operating voltage at Boulder ..	230	kV
Operating voltage at Chino ..	216-220	kV
Total line loss at 165,000 kV ..	19,000	kW
Charging current	48,000	kVA
Charging current loss	600	kW
Corona loss, not over	500	kW
Line efficiency at 165,000 kW (per cent.)	89	%
Annual efficiency at 900,000,000 kWh (per cent)	92	%
Corona loss with one wire grounded not over	25,000	kW

Over-all lowest annual cost for the transmission were found for 605,000 circular-mil aluminium-steel-reinforced conductors. The line has a horizontal configuration (all 3 conductors in one plane), with a spacing of the conductors of 23 ft. and an average height of 45 ft. Two $\frac{1}{2}$ in. seven strand steel ground wires are located midway between the conductors and 20 ft. above the line conductor plane.

Service Protection Features.

Reliability of service requirements on this line were met: (1) by the installation of two overhead ground wires; (2) by the installation of counterpoises at towers with footing resistances in excess of 100 Ohms; and (3) by the installing of ground-fault neutralizers at the terminals of the line.

From long years' experience it was estimated that less than one flashover a year could be expected with the line equipped with two ground wires. This flashover would be limited to a single line-to-ground type of flashover, if tower-footing resistances were reduced to 100 Ohms or less. Counterpoises of 200 ft., parallel to the line in both directions, were installed at all towers exceeding 100 Ohms in footing resistance. As a result the maximum resistance did not exceed 70 Ohm. The average resistance is in the order of 18 Ohm.

In order to deal with other faults involving one conductor and ground, ground-fault-neutralizers (Petersen coils) were installed as an appropriate protective device.

General Application-requirements for Ground-fault-neutralizers.

The Boulder-Chino line was not to be metallically interconnected with the other 230 kV lines of the system. Therefore it was not necessary to provide isolating transformers, when neutralizers were installed. Furthermore, all new apparatus was to be purchased for the new line, so it could be specified to have the necessary insulation levels required, when neutralizers were used. Accordingly the lightning arresters were specified for full line-to-line voltage, and have a maximum permissible line-to-ground voltage rating of 242 kV. All transformers had to be provided with neutral insulation in the 138.000 V class.

Application and Design.

For 234 miles of 230 kV line the estimated charging current was 301 A. This figure included the effect of the formation of corona (approx. 3.5% increase of current). Charging current in the case of ground-fault was found to be 2.17 times the normal three-phase charging current. It was expected that the measured current would be 5 to 10 higher than the current calculated, as a consequence of the capacitance of the towers, insulators, transformers, etc. Measurements showed the actual charging current to be 314 A for 234 miles of line.

Three transposition barrels were incorporated in the design of the line, which eliminated the unbalance in the system neutral-to-ground voltage otherwise connected with the arrangement of the conductors of the line. The test showed that the line was well balanced with these trans-

positions, as the neutral-to-ground voltage with the neutralizers in service was less than 1000 V.

The corona losses, on condition of one wire at ground potential and the other two at line potential to ground was computed to be 15.000 kW for 234 miles of line of the conductor size selected and the line transposed. The unsuppressed fault current corresponding to this corona loss was 59.4 A, a current which it was believed would not maintain the arc with the arcing distances involved. This was justified by the tests made. They gave a fault current on solid ground fault between 60 and 70 A on the 234 miles section of the line.

Ground-fault-neutralizers were planned for the Boulder Dam, Chino and Barre transformer neutrals. Chino and Barre neutralizers were designed to compensate each for one third of the total length of line, the Boulder neutralizer has a double winding mounted on a single magnetic core, each winding designed for operation either singly or in multiple, with the other and to compensate for a third of the total length. By this arrangement the station operator in Boulder Dam is enabled to replace one of the other neutralizers, which may have come out of service.

Fig. 2 shows the ground-fault-neutralizer at Boulder Dam, installed between the 27.500 kVA

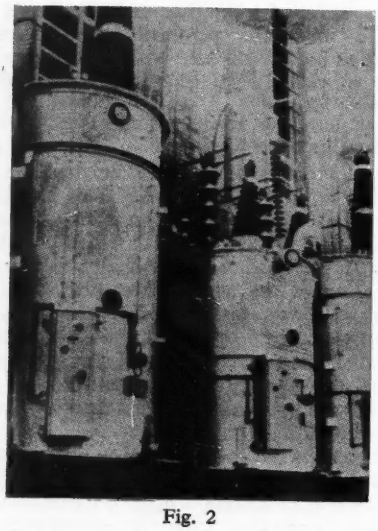


Fig. 2

Ground-fault-neutralizer, 230 kV, 100/135 or 200/270 amperes, 50 cycles (centre) on line of Southern California Edison Company, Ltd., at Boulder Dam.

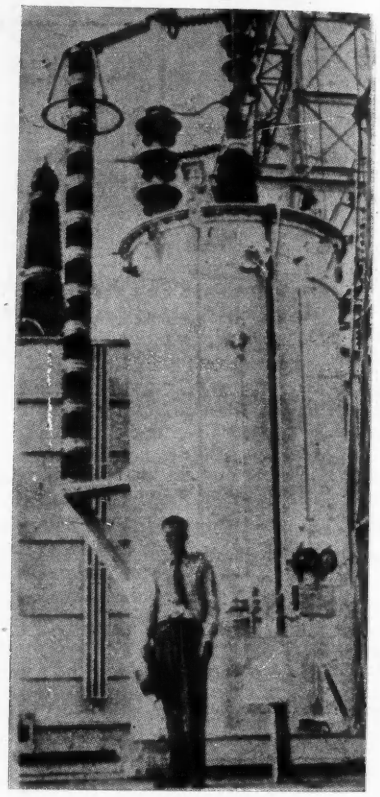


Fig. 3

Ground-fault-neutralizer, 230 kV, 100/135 amperes, 50 cycles, in Barre substation of the Southern California Edison Company, Ltd.

230 kV transformers, feeding this line. Fig. 3 shows the neutralizer in Barre substation. All neutralizers were specified to have a current range of 100 to 135 A at 50 cycles, with 20% additional current capacity at 60 cycles. The impedance can be adjusted by manually operated tap changers in steps of 10% from minimum to maximum current rating. The neutralizers are suitable for carrying rated current on any tap for 10 minutes. Each neutralizer was equipped with a 138 kV bush on the transformer end and a 15 kV bush on the ground end of the winding. The Barre neutralizer is equipped with a Thyrite station-type lightning arrester (it can be seen in Fig. 3), the two other neutralizers have Thyrite by-pass resistors.

Auxiliary Equipment.

The auxiliary equipment of each of the neutralizers consists of an instantaneous overcurrent relay, a timing relay and an operation-recording device. The operating procedure during permanent ground faults will be to keep the line energized up to possibly the full time rating of the neutralizers, so that the power, which is to be lost upon opening this line, can be picked up on the other generating stations of the system.

Tuning and Arcing Tests.

Tuning curves were taken in two different ways, first for the Boulder Dam-Chino line and, later, for the whole system. Minimum current in artificially made ground faults varied between 60 and 70 A for 234 miles of line. For the total system the uncompensated fault current was of the order of 80 A.

A series of arcing tests were made by short-circuiting a 14 unit insulator string suspended from a spur line in the Chino substation and similar tests were made in Boulder Dam. Average arcing time was 1.5 sec. The arcs to ground were suppressed without any system disturbance or circuit breaker operations. Inspection of the aluminium line conductors after the arcing tests disclosed absolutely no burning or pitting of the conductors. Only a few bright spots were visible.

Summary.

The service continuity record of this new single circuit transmission, equipped with ground-fault-neutralizers, is expected closely approaching that which heretofore was obtainable only by two transmission lines located on separate rights of way with cross-over and paralelling switching stations. With this new design, flashovers caused by lightning are expected to be reduced to single line-to-ground faults by the two overhead ground wires and counterpoises and suppressed by the ground-fault-neutralizers. Permanent ground faults are not to be removed immediately, but are to be allowed to remain on the line until the load can be backed off the Boulder Dam generators.

The installed cost of the ground-fault-neutralizers is less than 5% of the cost of a second line.

AIR-BLAST BREAKERS IN SWITZERLAND

By F. PETERMICHL. (From *Elektrotechnische Zeitschrift* (ETZ), Vol. 61, No. 52, Dec. 26th, 1940, pp. 1192-3.)

THE Swiss electrotechnical manufacturing companies have developed during recent years air-blast breakers embodying the principles of the German types of such apparatus. The use of these breakers exerted a great influence upon the design of the switch plants of power stations, as the danger of fire and smoke was removed by the use of oil-less breakers, and the forms of circuit connection was simpler than with oil circuit breakers.

For the production of compressed air a uniform practice has been accepted. The compressor works on a central container, in which the compressed air for a certain number of breaker operations is stored. The air is distributed from there to the breakers, the pressure being regulated by reducing valves. A storage of air for six makes and breaks of the first breaker and for two cycles for each following breaker is considered as sufficient. This seems to be very considerable according to German experience.

There is no conformity between the opinion of the designers in regard of the pressure to be used. Whereas A. Roth (Sprecher & Schuh) asserts, that the most economical pressure is below 10 kg/cm² (*Bulletin de l'Association Suisse*, 1939, pp. 653), it is the opinion of H. Thommen (Brown Boveri), that one has to use a high pressure in order to get an economical breaker (*Bull. Ass. Suisse*, 1939, p. 702). A great number of plants working with a pressure up to 15 kg/cm² caused no difficulties. Orlikon, too, uses pressures between 10 and 15 kg/cm².

Contact burning in air-blast breakers is low with heavy as well as with light load breaks. No surges occur, when capacitive load is disconnected and the surges following the disconnection of transformers on no load are not higher than with oil circuit breakers.

The Swiss firms use the same system for the extinction of the arc as applied in Germany, where the air-blast breaker had its origin. The arc is enveloped by a coaxial blast of compressed air through a nozzle.

Two types of nozzles are used in Germany. The **contact-nozzle,** which functions at the same time as a contact and as a nozzle, used for voltages up to 45 kV, and the **insulating nozzle**

of the open-jet breakers for voltages over 30 kV, which is made of insulating material, the contact being made outside of the nozzle.

Only contact nozzles are made in Switzerland. Whereas in Germany only the simple form of the nozzle (Fig. 1) is used and higher rupturing capacity is achieved by larger dimensions of the nozzle or by the use of a higher pressure, the Swiss firms apply additional elements as hollow contact rods, movable nozzles and additional resistors (1).

Fig. 1
Single nozzle.

Fig. 2.
Nozzle with auxiliary arc gap.

Fig. 3
Double nozzle.

The Brown Boveri breaker is manufactured either for mounting on the wall or as self-contained type. For high rupturing capacity indoor breakers, a two-gap arc extinction with resistors are used. In the latest design these resistors do not form a part of the curcuit in normal breaks occurring under ordinary working conditions. They are switched in only in heavy breaks by the metal vapours blown up to an auxiliary arc gap (Fig. 2). The 150-kV open air breaker contains no resistors, but works with two air gaps in series, placed in the upper hollow insulator columns. An isolator switch is attached which is used for the closing of the circuit, the nozzle-contact of the switches being in the closed position, when the breaker is open.

A special single pole air-blast breaker has been developed for locomotives, based on the same principles of design. It proved to be superior to the oil-circuit breaker.

For the installation of single breakers Brown Boveri uses an air-blast breaker of low rupturing capacity, which comprises an individual little compressor.

(1) See *The Engineers' Digest*, Vol. 2, No. 1, pp. 14/16: Air-blast Circuit Breaker with Paralleling Resistor.

During recent years the air-blast breakers were tested thoroughly in regard of their suitability for outdoor installation. Test plants comprising 150 kV breakers were erected on the Jungfrau-Joch and on the summit of the Säntis, where the breaker was exposed to high humidity and to extremely low temperatures. It was stated that neither the breaker nor the compressed air plant caused difficulties, when properly designed.

Oerlikon uses for breakers up to 38 kV a wall type, with a single nozzle for low rupturing capacities (Fig. 1) and with a so-called double nozzle (Fig. 3) for high rupturing capacities (see O. Naef, *Bull. Ass. Suisse*, 1939, p. 677). In these nozzles the compressed air escapes through the fixed contact nozzle upwards and through the hollow movable contact rod downwards. The air which escapes downwards, enters a closed storing chamber and escapes after the break is accomplished through the contact nozzle upwards, too. For even higher rupturing capacities an extinction with two gaps and resistors is used similar to the Brown Boveri design. In the simple nozzle the resistor is put into the circuit by the arc, when it is blown upwards and comes in touch with an auxiliary nozzle (Fig. 4), in the double nozzle the insertion is

Fig. 4
Nozzle with auxiliary electrode and resistor.

Fig. 5
Double nozzle with resistor.

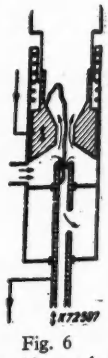


Fig. 6
Double nozzle; the upper nozzle works as a rapidly opening contact.

achieved by a contact in the lower part of the nozzle (Fig. 5). For large breakers, especially for high voltages, Oerlikon uses a double nozzle, with a movable part (Fig. 6). The contact nozzle is lifted by the air pressure to a distance, which is sufficient for the extinction of the arc.

A. Roth described an air-blast breaker

which itself produces the compressed air by means of a spring and a piston. Such breakers are suitable to interrupt up to 10,000 A at 15 kV. But they are rather expensive. A breaker of this kind is designed as a sliding isolating switch. It has been applied extensively in 10 and 20 kV systems, but is used even up to 60 kV. For high rupturing capacities it is combined with high capacity fuses, which interrupt short-circuits. These breakers have a destination similar to that of the hard gas switch and hard gas power isolator switch of the A.E.G., Berlin.

One has recognised in Switzerland, as well as elsewhere, the importance of auto-reclosing for dealing with short-circuits and the great suitability of the air-blast breaker for this purpose (2). A great number of breakers for auto-reclosing will shortly be in use, especially in systems with very high voltages. In these breakers the extinction of the arc and the separation of the contacts to a distance necessary for the final break and isolation are achieved by different elements of the breaker.

In the Brown Boveri rapid reclosing breaker for 150 kV only the contacts are separated at first. The isolator is opened only after the second short-circuit, when the final break has to be made.

The Oerlikon rapid reclosing breaker too uses a movable nozzle contact for the extinction of the arc.

All Swiss breakers for high voltages have insulator columns, and are combined with isolator switches. In Germany the insulated nozzle enabled the creation of the open-jet breaker, which can be used without isolator for voltages of 30 to 400 kV.

(2) See *The Engineers' Digest*, Vol. 1, No. 6, pp. 220/22: Air-blast Circuit Breakers as a means of dealing with short-circuits by auto-reclosing, by G. Brockhaus.

FINE ADJUSTMENT FOR ELEVATORS BY STEP SWITCH

By K. SCHMALZ. (From *Siemens' Zeitschrift*, April, 1941, pp. 114-119).

FOR many elevator installations it is essential that the cage should be stopped flush with the floor. This is the case for instance in hospitals, warehouses, where loading or unloading of the elevator is much easier if there is no step between floor and elevator cage. For this reason a fine adjusting arrangement is essential which will stop the elevator at the exact position, regardless of the loading or direction of travel. It is advisable to keep the kinetic energy imparted to the elevator motor as low as possible, and practice showed that for such, working speeds of 0.1 m/sec. are suitable.

A satisfactory solution of the problem is obtained by employing a step switch. Apart from the usual machinery this results in only a little extra complication, and can be fitted also to existing elevator systems. The principle of this step-switch is to transmit one or more short energy impulses to the motor, which produce rotations of only fractions of one revolution. These small movements bring the elevator to the required position.

In other words, by adopting this method, uniform travel is dispensed with; but this is not an important factor, since care is taken to keep the speed of the individual motions within such limits that accurate stopping of the elevator is possible, at the same time the passengers experience only slight speed variations, which do not cause feelings of discomfort.

Operation of the Step-guard.

The speed of the elevator is controlled by a step-guard, shown in Fig. 1. It is essentially a short circuited rotor, mechanically coupled to the elevator motor, and its stator has a limited freedom of rotation. The stator is provided with a D.c. electro-magnet. The increasing speed increases the rotor current and this, together with the electro-magnet, produces a torque acting on the stator. A spring controlled lever is fixed on to the stator and controls various switches which are consequently operated at various speeds of the rotor. These switches control the circuits of

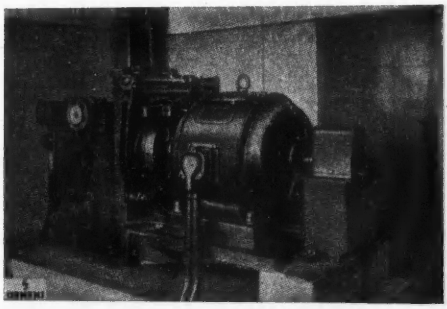


Fig. 1 Step guard motor.

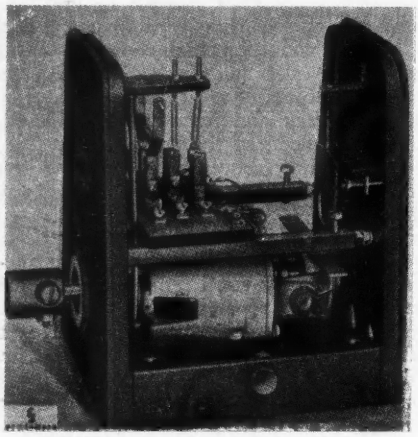


Fig. 2 Step guard with cover removed.

the various auxiliary mechanisms, such as relays, protectors, etc.

The speed control of the elevator by the step-guard is obtained in the following way. At a pre-determined speed of the motor, the step-guard interrupts the circuit to the motor. If now, according to the loading and direction of motion the speed is falling, the step-guard closes the circuit at a minimum speed. This process is repeated until the elevator is brought to rest at the required position. Should, however, the speed continue to increase, a brake is additionally applied to the motor shaft until the speed is again reduced to a minimum value, when the brake is released and the current is switched on again. The step-guard is so adjusted that it prevents higher speeds than those at which accurate stopping of the elevator is possible. In this respect consideration should be given to the loading which would produce maximum speed, i.e., full load on downward travel. The intermittent energy impulses given to the motor should be as long as possible in order to reduce the number of steps required to bring the elevator to the required position. A current impulse results in the longer a step the smaller the downward accelerating force. This in turn depends not only on the loading but also on that portion of the turning moment of the motor which is available for acceleration after overcoming the static friction of the motor. Consequently, the dimension of the motor should be kept low. If this is not possible (existing scheme), a permanent resistance may be connected in the motor circuit. This solution is not quite satisfactory, as the speed would drop too rapidly when fully loaded on downward travel. The total path during which the step-guard is operating is only about 8 cm., and is covered by about 3 energy impulses.

The step-guard can be equally well applied to A.c. and D.c. motors, in both cases a resistance being connected in the circuit such that it keeps the current at a value that will just start the motor under the most unfavorable loading conditions. The speed of the elevator has little effect on the applicability of this system, since, as mentioned before, only a small portion of the travel is affected by the action of the step-guard. Nevertheless, it is advisable to reduce the speed of the elevator first, if it has a greater speed than 0.7 m/s.

The step-guard with cover removed is shown in Fig. 2. The stator and the rotor are mounted on the same shaft, which is coupled by a spring coupling to the motor. The rotation of the stator is limited by two stops, and an adjustable spring brings the stator to the central, neutral position. Oscillation is damped out by a small felt-brake. To change the direction of rotation an interrupting contact is provided and another switch operates the lever lifting the brake from the drum. Depending on the direction of rota-

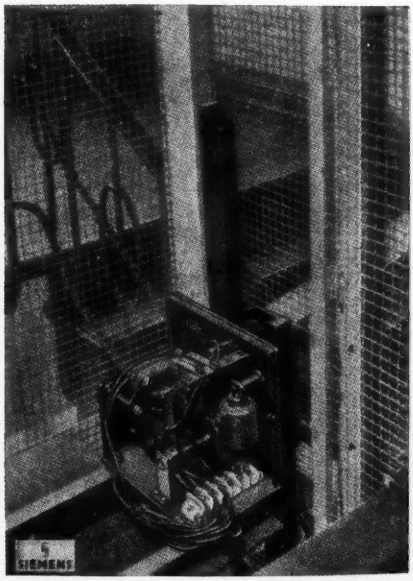


Fig. 3 Flush switch with stop disc.

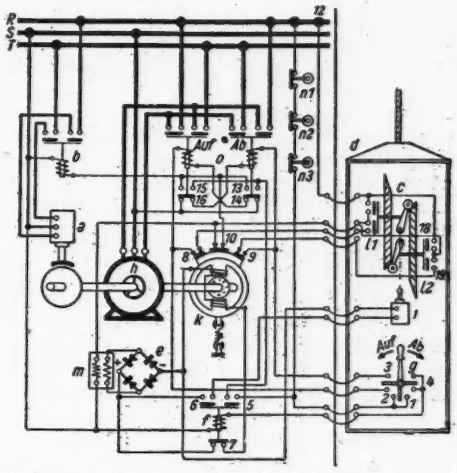
tion, the stator opens first the switch-over contact and then the contact for the brake lever. The stronger the excitation of the field, the smaller is the speed required to start the apparatus.

Regulation of the step-guard can be obtained by (1) adjustment of the field excitation; (2) adjusting the balancing spring; and (3) varying the distance between the switches operated by the lever. The step-guard has no part liable to excessive wear, hence its reliability of operation.

While the step-guard is controlling the speed of the elevator a "flush stop-switch" stops the elevator cage at the exact position; its duty is therefore to switch off the current to the motor when the cage is flush with the floor. The flush-stop is fixed to the cage and is provided with two roller levers which work in conjunction with stop discs fixed to the pit. One of these roller levers is pushed back during upward travel, closing the circuit to the motor. When the cage reaches the required position the lever comes to the neutral position cutting off the current. Should the cage pass the flush position, the second roller lever is pushed back by the stop disc, and starts the motor in the reversed direction.

To prevent undue wear of these roller levers, they are withdrawn during the rapid motion of the elevator and are brought into working position at the required floor.

A diagram of connection is shown in Fig. 4. It can be seen that while fine adjustment of the cage by means of the step-guard is possible with open doors, for fast travel the doors should be kept closed.

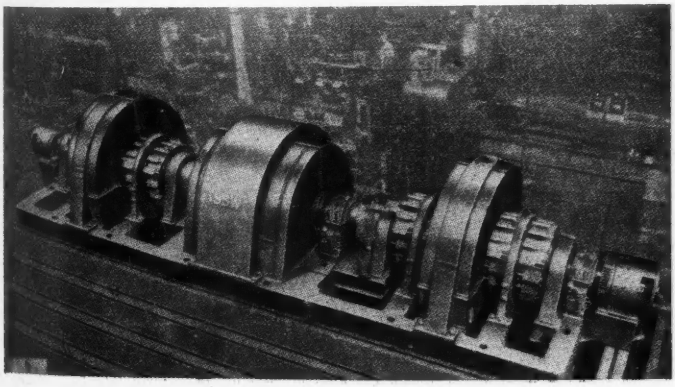


(a) Brake reliever; (b) Brake reliever magnet; (c) Flush switch; (d) Elevator cage; (e) Dry rectifier; (f) Auxiliary switch; (g) Operating lever; (h) Elevator motor; (i) Magnet to withdraw roller levers; (k) Step guard; (l 1 and l 2) Stop discs in pit; (m) Transformer; (n 1, n 2 and n 3) Door contacts; (o) reversing switch.

Fig. 4. Connection diagram.

Peak Result in D.c. generator construction.

THE Siemens-Schuckert Werke has completed an order for a generator consisting of two D.c. generators with a total output of 32,000 amps and 200 volts in parallel connection, and 16,000 amps 400 volts in series connection, and a common synchronised motor for 6900 KW 6200 volt, 50 cycles and unity power factor. Regarding the current intensity this machine is claimed to have a high performance. The overall efficiency is claimed to be 90.7% made up from 93% for the generators and 97.5% for the driving motor. The illustration shows the generator on the test bench. Each generator has two double commutators, and each bearing stool has a pressure oil bypass installation for easy starting. The examination proved that the generators were running spark-free under any loading condition.



HORIZONTAL DIESEL ENGINES FOR MOTOR COACHES

By KURT HENZE, Kiel. (From *Zeitschrift des VDI*, Vol. 84, May 15th, 1940, pp. 565-568).

FOR economy of floor space the horizontal type of engine has been employed recently by the German Reichsbahn. The engines are mainly two-row Diesel engines, the two sets of cylinders driving a common crankshaft. Figs. 1 and 2 show the general arrangement of a 6-cylinder vertical and an 8-cylinder horizontal engine respectively. Both types have an output of 180 h.p. at a speed of 1500 r.p.m. A comparison of the two types of engines shows the following differences: (1) The useful flooring taken up by the vertical type is about $2m^2$, but with the horizontal type, nil. (2) The flooring of the carriage cannot be lowered to such an extent with the horizontal engine as with the vertical engine. (3) The horizontal type has a smaller overall length and consequently a shorter wheel base. (4) Dismantling of the engine is much simpler with the horizontal type, since the carriage need not to be lifted; the engine is only disconnected and taken out at either side of the carriage. (5) Access to the cylinder head is unhindered in the case of the horizontal type, while in the case of the vertical type the guard inside the carriage has to be removed first.

For higher outputs V-engines are employed frequently. This reduces the length of the wheel base, but there is no saving in height compared with the vertical type of engine.

Constructional Details.

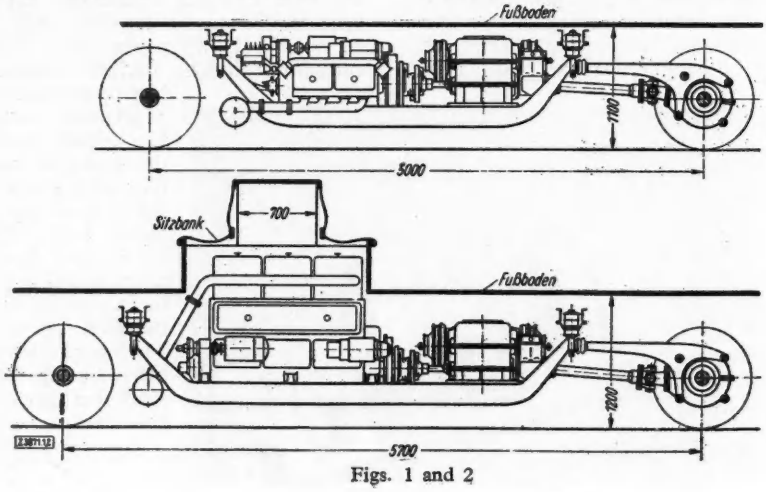
The crankshaft is situated mid-way between the two banks of cylinders. For mounting the crankshaft to an 8-cyliner engine, the crank case is cast in one piece. It is provided with two access holes through which the crankshaft is brought into position from the fly-wheel side of the casing. With horizontal engines having more than 8 cylinders, owing to the angular displacement of the crank webbs, the openings on the crank case would become excessive, therefore, the crank case is built up from two parts bolted together.

The piston rods of two oppositely situated pistons are connected to the same crank pin, and for kinematic reasons one of them forms a fork enclosing between its two arms the other piston rod. The forces are completely balanced with a two-row 8-cylinder engine.

The horizontal design requires different mountings for the injection pumps. These are mounted either horizontally on the crank case, or vertically on the front of the engine block, facing the fly wheel. With the first solution it is better to arrange them parallel to the cylinders, but need in this case bevel gearing for the drive. Each row of cylinders has a separate pump housing, but a common camshaft is employed.

180 H.P Two-row Engines.

Figs. 3 and 4 show the arrangement of such an engine. They have a stroke of 180 mm. bore of 128 mm., and a speed of 1500 r.p.m. The beginning of injection is automatically controlled independent of the speed. Monobloc



Figs. 1 and 2

construction is utilized, and an electric starting motor working on 110 volts.

Later types employ anti-chambers to simplify the change over to a different type of fuel.

275 H.P. Two-row Engines.

The engine is shown in Fig. 5. Its specification is stroke 190 mm., bore 130 mm., speed 1500 r.p.m., and each row consists of 6 cylinders. The cast iron cylinder block is made from two parts bolted together. For easy starting the anti-chambers are fitted with glow plugs. The governor arranges for a uniform no load and full load speed, intermediate speeds being hand regulated. The air-filters are mounted to the engine in a special casing from which an air trunk is carried to a high point of the carriage to ensure a dust-free air intake.

Improved efficiency is obtained by using exhaust gas turbo-blowers for supercharging. This

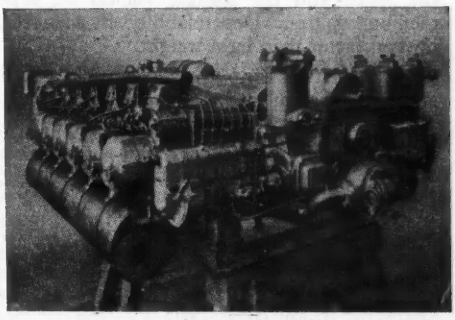


Fig. 5

raises the output to 400 h.p. Two turbo-blowers are provided for each row of cylinders and are fitted in place of the air filters.

Practice has shown that for a long working life

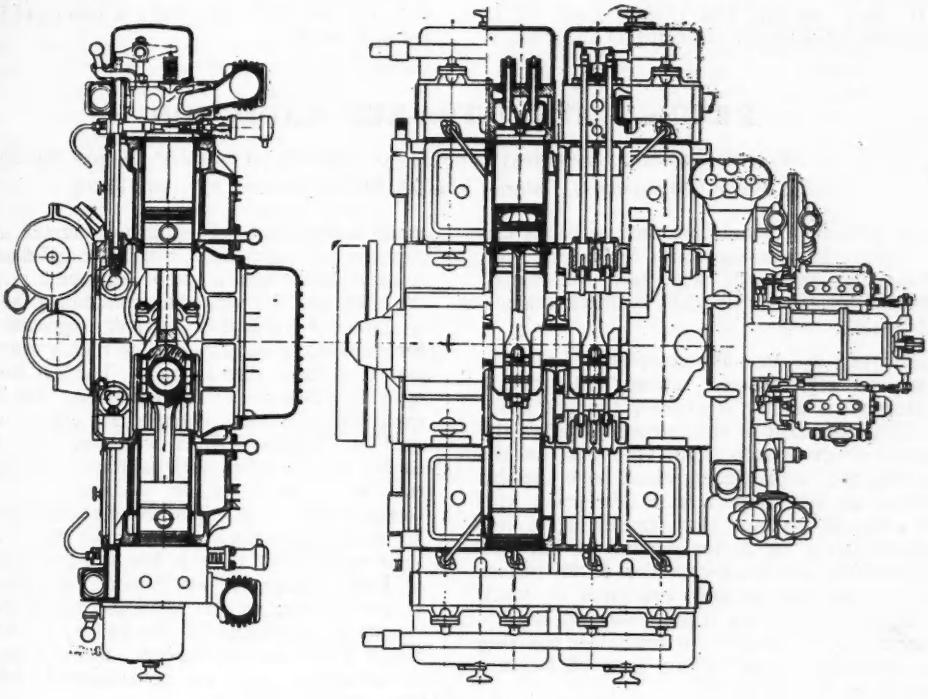


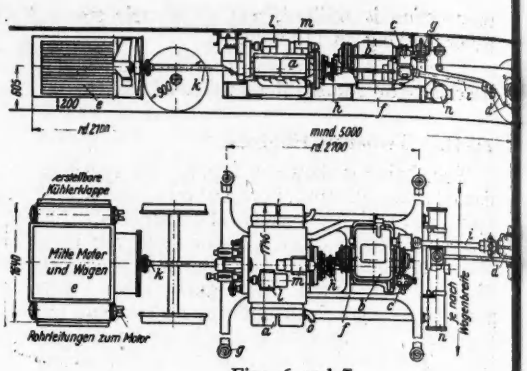
Fig. 3 and 4

the speed and the loading should be kept to medium values. Dependability is a more important factor than light weight.

Particulars of the successfully employed Diesel engines are given in Table 1.

TABLE I

	8-cylinder engine	12-cylinder engine	12-cylinder engine supercharged
Cylinder diam mm	128	130	130
Stroke mm	180	190	190
Working power HP.	180	275	400
Working speed r.p.m.	1500	1500	1500
Weight kg	1330	2300	2450
Cyl. volume l	18.5	30.5	30.5
Output per cyl. vol. HP/l	9.75	9.0	13.1
Average working pr. atm.	5.85	5.5	7.92
Weight per HP. kg/HP.	7.4	8.7	6.1



Figs. 6 and 7

Figs. 6 and 7 show the mounting of the engine and transmitting gearing into a two-axle motor coach. Motor and drive are built in a common frame, mounted on rubber in the undercarriage. The drive has four speeds in both directions. The reversing gear and the changing gear are mounted in the same casing. The toothed gears are in permanent engagement, changing of the gears is by means of a disc clutch operated by compressed air. The compressor and the brake are mounted on the drive. It can be seen that the entire driving mechanism is under the carriage floor and takes up no useful flooring. With standard gauge railways the height of the floor above ground level is about 1700 mm. and a minimum of 5 m. gauge is possible.

DRYING WITH INFRA-RED RADIATION*

By H. F. DAVIDSON, Photometric Laboratory, H.E.P.C., of Ontario. (From *The Bulletin The Hydro Electric Power Commission of Ontario*, Vol. 28, No. 1, January, 1941, pp. 15-24).

GREAT reduction in finishing time of paints can be attained if paints suited to the baking with radiant heat are used. The most widely-used industrial finishes are lacquers, synthetic enamels and japans.

Lacquers are generally composed of plastics, plasticizer, pigment and solvent. The drying of lacquers is almost completely brought about by the evaporation of the solvent. Neither the plastic, which actually forms the film on the material, nor the plasticizer, which keeps the film flexible, are very important in connection with the infra-red drying. The pigment is of importance in so far as the amount of infra-red heat absorbed depends a great deal on the surface colour. Lacquers contain sometimes as much as 75% solvent. They require low heat density. Temperatures over 150° Fahr. may cause bubbling or pin-holing. Usual drying time of lacquers amounts to 4 or 5 minutes.

Not all synthetic baking enamels are suited to the use of infra-red radiation. Among the usual components of synthetic enamels, i.e., pigment, oil, resin, drier, plasticizer and thinner, greatest importance is to be attributed to pigment, oil and thinner, when considering the use of infra-red radiation. Organic pigments are heat-sensitive generally, and too high a temperature may cause discoloration. The oils harden by polymerization or by oxidation. For high speed baking enamels polymerizing oils are used, such as Tung—or china wood oil. Oils that harden by oxidation, such as linseed, are generally not suitable, as the oxidation process is comparatively slow. The baking temperatures for synthetic enamels range from 200 to 325° Fahr. with drying times as low as a few minutes.

Baking japans are not generally adaptable to radiant heating as the vegetable oil, which is usually a component of the japans, requires a rather long time to harden. Some japans of the air-drying variety can be hardened by radiant heat without difficulty.

*Partial abstract of this publication, covering the chapter: Paint Baking.

DEVELOPMENT OF FLOTILLA LEADERS SINCE 1914

By DIPL. ING. WILHELM HADELER. (From *Zeitschrift des VDI*, Vol. 21, No. 1, 18th January, 1941, p. 65).

THE destroyer leader has been developed from a class laid down only a few years before the Great War. It has been created by the enlargement and reinforcement of the ordinary destroyer. As a consequence the new type is not even mentioned in the London Naval Agreement of 1930. It was merely stated that not more than 25% of the total tonnage of destroyers permitted to the signatories of the pact should displace between 1500 and 1850 tons. The maximum calibre of the guns was fixed as 13 cm. or 5 in.

British "Flotilla Leaders."—The first destroyer leader was constructed by British Navy. The first ship of this type was the "Swift," built in 1908. The average destroyer had a displacement of 800 to 900 tons, and 30 to 33 kn. speed, two 4 in. or correspondingly more 3 in. guns. The new boat displaced 1825 tons, had a speed of 36 kn., and the armament consisted of four 4 in. guns and two 18 in. torpedo tubes. The strengthening of the armament did not compensate for the increase of the tonnage and this was probably the reason why sister ships were not laid down. It was only in 1914 when the budget provided again for the construction of this type of ship. The ship should still be a destroyer but as a leader with destroyer speed bear a heavier armament and should offer accomodation for the flotilla staff by its greater displacement. These demands were fulfilled by the "Marksman" class (Table I.). The experience with this class during the Great War lead to the "Shakespeare" class (Table I.), which was only finished in 1920. Then followed a period until the flotilla leader "Codrington," was launched in 1929. Here the torpedo armament was increased by two 21 in. tubes, and consequently the S.H.P. had to be increased by 1000 H.P. The following flotilla leaders had a displacement increased by only 100 tons ("Tribal class"). These ships were probably designed as destroyers for destroyers. Ever the more surprising is the news that the Cockatoo-Island shipyard is building flotilla leaders with 6 in. guns.

The German Navy.—Up to the present the Germans have not created a type of boat destined to accommodate the flotilla staff. The good results with the "B 97" class during the Great War inspired the construction of the big boats "S 113/15," "V 116/18," "G 119/21," "B 122/24," (Table II. and Figs. 1 and 3) which although still destroyers had certain qualities of light cruisers. Of these boats only the "S 113" later transferred to France and the "V 116" transferred to Italy have been finished. In 1935 the German navy ordered 16 new big destroyers, which seem to continue the "S 113"

Fig. 1 German "Big Boat," 1916.

TABLE I. **British "Flotilla Leaders."**

Name of type-ship	Marksman	Shakespeare	Codrington	Keith	Faulknor
Number of boats	4	7	1	1	1
Launched in year	1915	1917	1929	1930	1934
Displacement		1480	1540	1400	1475
Design displacement	1500	1740			
Max. displacement		2050	2000	2000	2000
Length metres	99.06	100.3	101.2	98.5	103.4
Width "	9.45	9.68	10.3	9.8	10.3
Draught "	3.37	3.04	2.7	2.59	2.65
Armament guns	4/4 in.	5/4.7 in. L/50	5/4.7 in. L/50	4/4.7 in. L/50	5/4.7 in. L/50
A.A. "	2/40 mm.	2/40 mm. 1/3 in.	2/40 mm. 5 m/g.	2/40 mm. 5 m/g.	8 m/g
Torpedo tubes	4/21 in.	6/21 in.	8/21 in.	8/21 in.	8/21 in.
S.H.P.	36000	40000	39000	34000	38000
Designed speed, knots	34	36	35	35	36

Note: L refers to the length of the gun as multiple of the diam.

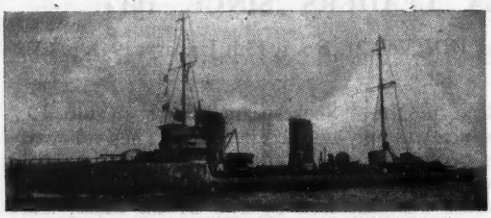


Fig. 2 German "Big Boat, 1916" "V 116."

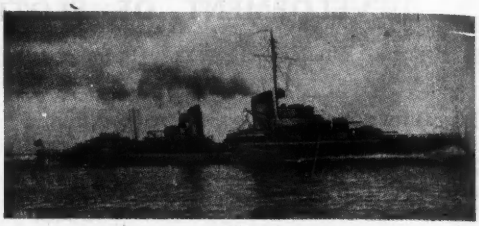


Fig. 3

class. Their armament consists of five 5 in. guns, eight 21 in. torpedo tubes in groups of four; displacement 1625 tons, length at water line 114 m., width 11.3 m. and draught 2.8 m. Fig. 3 shows the first finished boat "Leberecht Maass." Besides six more destroyers with 1811 tons displacement have been ordered.

TABLE II. "S 113" to "B 124" of the German Navy.

Length on the water line metres	106.00
Width metres	10.37
Draught under design displacement metres	3.78
Type displacement tons	1634
Maximum displacement tons	2323
S.H.P.	45,000
Speed knots	34.5
Armament	4/15 cm. A.A. L/45 4 m/g
Torpedo tubes	4/60 mm. in groups of four
Fuel oil tons	650

TABLE III. French "Contretorpilleurs."

Name of type-ship	Jaguar	Guépard	Gerfaut	Le Terrible	Mogador
Number of boats	6	6	12	6	2
Launched in year	1923	1928	1930	1933	in const.
Type displacement	2160	2460	2480	2569	2884
Design displacement	2360	2925			
Max. displacement	2700	3000	3150	3400	
Length on water lev.	119.2	132.28	129.3	132.4	
Width metres	11.0	11.5	11.84	12.2	12.6
Draught under type displacement metres	3.4	3.57	3.88	4.25	4.5
Armament guns	5/13 cm. L/40	5/13.8 L/40	5/13.8 L/40	5/13.8 L/50	6/13.8 L/50
A.A. guns	4/3.7 cm.	4/3.7 4 d.c.t	1/7.5 L/35 4 d.c.t.	4/3.7 4 d.c.t.	4/3.7
Torpedoes	6/55/2×3	6/55/2×3	7/55/1×3 2×2	9/55/3×3	9/55/3×3
S.H.P.	50,000	64,000	64,000	74,000	90,000
S.H.P. on trials	57,200	79,300	93,000	100,000	
Designed speed knots	35.5	35	36	37	38
Speed of the fastest boat knots	36.7	40.6	43.2	45.25	

Note: d.c.t. refers to depth charge throwers.

The French "Contretorpilleurs." — In France strong emphasis was laid on this new type. It was decided to design ships with a nearly cruiser-like armament and a limited torpedo armament with destroyer speed. The experience with the German "S 113" known under the name "Admiral Sènes" inspired the construction of the six boats of the "Jaguar" class (Table III.).

The six boats of the class are still real destroyer leaders. The following "Guèpard" class caused a sensation as two of the six boats reached 40.6 kn. Gradually the original idea of the flotilla leader disappeared and the cruiser-like vessel came into the foreground. Besides great emphasis was laid on high speed. "Le Terrible" belonging to one of the latest classes had a 45.25 kn. speed on trials. To-day the contretor-

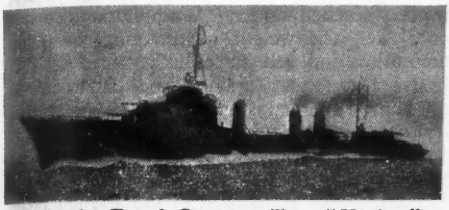


Fig. 4 French Contretorpilleur, "Verdun."

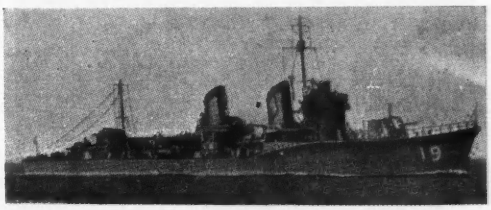


Fig. 5 Japan Destroyer of the "Amagiri" Class.

pilleurs have nearly reached the size of former small cruisers and their armament is now equal to the cruiser armament of the "Magdeburg" class of 1911. Lately it became known that the French navy intended to introduce a light splinter protection on the boilers and machinery. So the last connection with the torpedo boats would disappear.

Italian "Esploratori."—The oldest ships of this type were launched in 1914, nearly simultaneously with the English boats. The development of the ship's type can be seen from Table IV. There are some reports about the newest types which claim that the fastest boat "Nicoloso da Recco" has a displacement of 1850 tons or 222 tons above the displacement of her class and a speed of 41.5 kn. This boat is therefore equal to the modern French boats. According to American reports in another boat of this class, the "Antonio Pigafetta," a Sperry-gyroscope as stabilizer is installed.

TABLE IV. **Italian "Esploratori."**

Name of type-ship	Carlo Mirabello	Aquilla	Leone	Navigatori
Number of boats	2	2	3	12
Launched	1914	1916	1923	1928
Type displacements ts. ..	1383	1407	1526	1628
Designed displacements ts. ..	1540	1500	2000	2010
Length on the w.l. m.	103.6	94.7	109.6	107.7
Width m.	9.7	9.5	10.3	10.2
Draught under type displacement m.	2.8	3.1	2.8	3.2
Armament	8/10.2 cm. L/45	4/12 cm. L/45	8/12 cm. L/45	6/12 cm. L/50
A.A. guns	2/40 mm. 4 m/g	2/7.6 cm.	2/40 mm. 4 m/g	4/3.7 cm. 8 m/g
Torpedo armament	4/45/2×2	4/45/2×2	4/53.3/2×2	6/53.3/2×3
S.H.P.	39,000	39,000	42,000	50,000
Speed in knots	35	33.9	34	38

Other Navies.—The Japanese navy built 23 big destroyers during 1927 to 1931, each of 1700 tons (Table V.). No details about these ships are known. The guns of the ships seem to be built into turrets, but it is thought that they do not represent anything more than a protection against weather or machine gun fire from low flying planes.

TABLE V. **Remarkable Flotilla Leaders of other Navies.**

	Japan	Phelps U.S.A.	Dubrovnik Jugoslavia	Tromp Holland
Type displacement	1700	1850	1880	3350
Length on the w.l. m. ..	112	113.4	113.3	132
Width m.	10.3	11.05	10.68	12.4
Draught m.	3.0	3.1	3.6	4.4
Armament	6/12.7 cm. L/50	8/12.7 cm. L/38	4/14 cm. L/50	6/15 cm.
A.A. guns	4 m/g.	4/10 mm. 8 m/g.	2/8.3 cm. 6/3.7 A.A. 2 m/g.	4/40 mm. 4 m/g.
Torpedo tubes	9/53.3 3×3	8/53.3 2×4	6/53.3 2×3	6/53.3 2×3
S.H.P.	40,000	50,000	42,000	50,000
Designed speed kn.	34	37	36.5	32.5
Fuel oil storage tons	420	500	?	860

Fig. 6 Jugoslav Destroyer-Leader, " Dubrovnik."

America first undertook the construction of flotilla leaders in 1934 by building 13 ships of the " Phelps " class. The duties of these ships were similar to the British. Two ships should still be mentioned: the Jugoslav " Dubrovnik," and the Dutch Flotieljeleider " Tromp." The Dubrovnik is a very large destroyer which had already cruiser tasks to fulfil, the Tromp has a light cruiser armament and also a light armour protection.

Both in construction and installation these ships are similar to ordinary destroyers. Surprising therefore, are the top speeds of the French destroyer leaders, which might cause the impression that other navies have not quite as efficient ships at their disposal. The quoted figures are, however, reached under " Washington displacement," i.e., the weight of the guns including ammunition and accessories is replaced by fuel oil and feed water up to type displacement. The hourly fuel consumption is so great that after some hours running the displacement is considerably reduced and consequently the speed of the boat at the unchanged engine power is increased. This explains why the French boats show a certain superiority over vessels of other navies. The foregoing information shows that the development of the flotilla leader is still in progress. A complete separation from the destroyer has nowhere been reached. This type should fill the gap between the destroyer and the light cruiser which is already far too big for certain tasks.

Fig. 7 Dutch Flotiljeleider, " Tromp."

SELECTING SPECIAL MOTORS

By W. H. Fromm. (From *Machine Design*, Vol. 13, No. 3, March, 1941, pp. 51-54).

Specially designed lightweight fractional horsepower motors have assumed considerable importance in applications where reduction in weight is an outstanding consideration. Airplanes are a prime example of the importance of weight reduction in auxiliary motors and equipment. Portable machinery is another field in which much thought must be given to weight, and in this type of application the weight of the motor is again a consideration.

Closely related to reduction of weight is reduction of size. On some aircraft applications, size and weight receive equal attention. Although a reduction in one generally results in a reduction in the other, it is sometimes necessary to keep both points in mind.

Since the aircraft industry is probably most concerned with weight reduction, a discussion of fractional horsepower aircraft motors will cover the principal points of lightweight motor design and construction.

A prime method of reducing the weight of an electric motor for a given output is to increase the armature speed. Because power is proportional to the product of speed and torque, an increase in speed, with the torque remaining constant, will result in an increase in power. This principle is employed in high frequency a.c. motors, since speed is proportional to frequency.

Series-wound d.c. motors have high-speed characteristics, and may be wound to operate on almost any direct-current voltage. The practical lower limit is six volts and the practical higher limit is 230 volts. In small motors the clearances between live parts and ground are so small that flashovers are likely to occur on voltages higher than 230.

Aircraft have for some time been equipped with a direct-current voltage supply obtained from 12 or 24 volt batteries.

Motors in which the armature and field are connected in series through a commutator can be wound to develop a given power output at almost any speed between approximately 1,500 and 20,000 revolutions per minute. On most aircraft applications speeds in the neighbourhood of 10,000 revolutions per minute are used. In some instances speeds as high as 18,000 have

been used, but since the idling speed would be close to 35,000 the motor is permanently connected to load to prevent its attaining a destructive speed. It should be noted that the series motor has a varying speed characteristic; that is, the speed is approximately inversely proportional to the load.

As compared to the moderate-speed series motor, shunt motor, or 60-cycle induction motor, the high-speed series motor is extremely light. It will be apparent, therefore, that the largest weight reductions may be obtained through the use of high operating speeds.

High-speed motors, naturally, are designed with built-in gearing of various types to provide a wide range of output speeds. Frequently, however, the motor purchaser prefers to buy the motor without gears and design the gearing into his machine. Gearing adds weight to the motor, but even considering this increase and the loss of efficiency through the gears, the weight of the complete power unit is less than that of an equivalent low-speed motor.

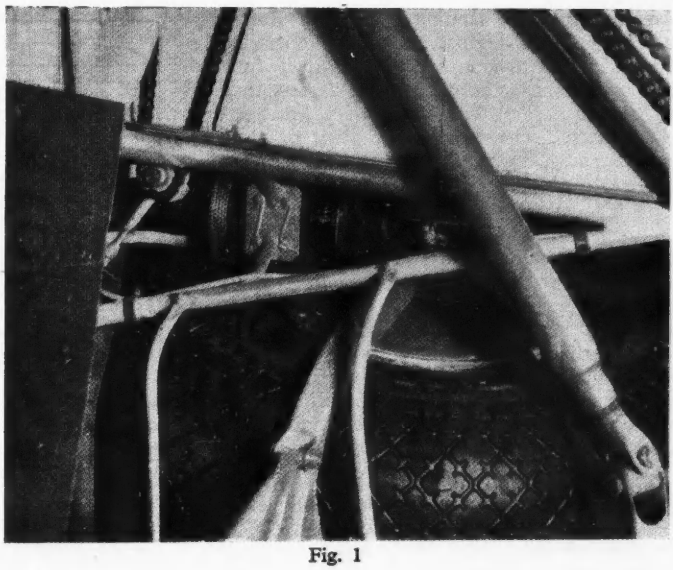


Fig. 1

Many aircraft applications, of course, require specially designed motors. When motors have been entirely redesigned for weight reduction, with the particular requirements of the application kept in mind, the savings in weight have been considerable. For example, when advantage may be taken of operating characteristics, such as intermittent duty and high speed, it is possible to accomplish weight reductions of as much as 25%.

Use of lightweight materials, such as magnesium and aluminium, are responsible for considerable reduction in weight of aircraft motors. Although the structural strength of these metals is less than that of cast iron this fact is not a serious disadvantage in the case of small motors since high strength is generally not required. Special treatments are frequently used to prevent corrosion—anodizing in the case of aluminium and pickling for magnesium.

The operating temperatures are mainly limited by the insulation of the windings. If insulation which will withstand higher temperatures without losing its insulating qualities is used, higher currents may be passed through the windings, and hence the power output may be increased. Therefore, if the allowable temperature rise may be increased the power output of a given motor may be increased or the weight and size for a given output may be reduced.

A reduction in weight and size could be achieved by using permanent magnets in place of the usual steel or iron pole pieces with wound coils, the weight of the coils being eliminated and the diameter of the motor reduced. For many applications a motor with a permanent magnet field would be entirely suitable.

Disadvantages of special lightweight d.c. motors for aircraft service include maintenance expense, relatively high cost, slow delivery and extensive development work. The commutator wears and must be refinished at intervals. Winding insulation deteriorates through age, temperature changes, moisture and vibration. All of these factors, which are not present or are present to a lesser degree in the d.c. induction motor, must be provided for in the use of the direct-current motor.

Applications of aircraft motors may be divided into two general classifications: those requiring high-torque intermittent duty motors and those requiring moderate-torque continuous duty motors. In Fig. 1 is shown a motor-

powered retractable landing gear on a Beechcraft biplane. A high-speed motor, operating through a worm gear reduction drive, fully extends or retracts the gear in a little less than four seconds. This single retractable gear increases the cruising speed of the plane by more than 20 miles per hour.

In the second classification are such devices as fuel pumps, oil pumps, anti-ice pumps, hydraulic pumps and blowers. Motors for these applications need not have high starting torque, but must operate continuously. They must be either ventilated or, if totally enclosed, large enough to prevent overheating. It is essential of course that fuel pump motors be explosion-proof, and other motors in this classification are frequently made explosion-proof, particularly on military airplanes. The performance curves of an explosion-proof continuous-duty motor are shown in Fig. 2.

Applications of electric power in aircraft are ever increasing. Hydraulic power has several advantages and is widely used but the electrical system is often lighter and is considered less vulnerable to gun-fire on military airplanes.

In conclusion it may be said that high armature speeds, lightweight materials and high operating temperatures are the principal factors in reducing motor weight. In selecting a motor for a particular application the designer should allow for as high an armature speed as possible within the limits outlined. Consideration should also be given to special temperature conditions since they might alter the amount of power the motor can develop or affect its weight.

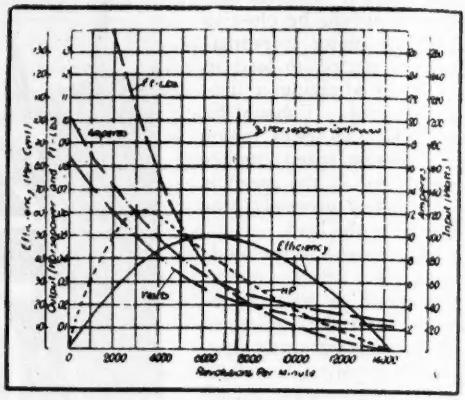


Fig. 2

Characteristic curves for a typical 12-volt motor used for continuous service as for pumps and blowers.

FULLY ENCLOSED A.C. ELECTRIC MOTORS FOR HIGHER OUTPUT

By K. A. LURENBAUM, Berlin. (From *Zeitschrift des VDI*, March, 1940).

THE increasing demand for special types of electric motors completely enclosed for protection against external influences on insulation and parts liable to deterioration, resulted in motors described below. These motors were mainly used for driving pumps—pump and motor being assembled in one unit. The motors were water cooled, the coolant being supplied by the first stage of the centrifugal pump. The stator sheets were enclosed in a cast iron cover with double walls, subdivided into a number of chambers through which the cooling water cir-

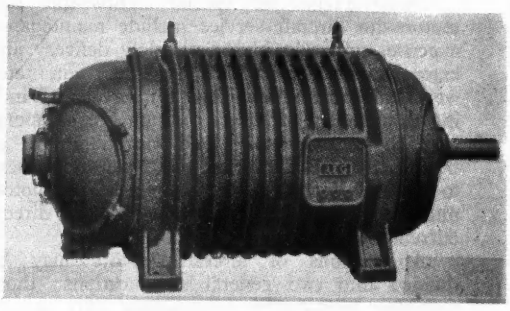


Fig. 1

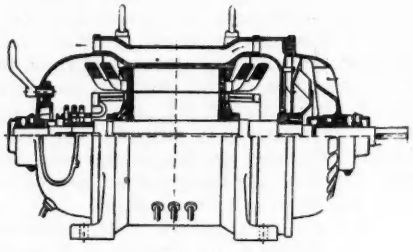
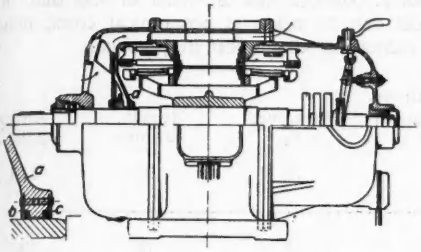


Fig. 2



a=cast iron cover; b=packing; c=felt joint.
Fig. 3

culates. The rotor is air cooled, the surface area being increased by ribbing (Fig. 1). The stagnant air surrounding the motor could not, however, provide satisfactory cooling and, as a consequence, a three phase motor has been developed with forced air cooling (Fig. 2); a fan fixed to the driving side of the unit forces an airstream along the casing. A recent type is shown in Fig. 3; the stator sheets are fixed to the ribs of the cast iron casing, the cooling air passes along the back of the stator sheets. Motors for higher output have a special surface cooler fixed to the casting (Fig. 4), the cooler being devided into chambers of rectangular cross section. To cool the radiator, a part of the airstream from the fan is turned back by means of an extension of the bonnet surrounding the ventilator.

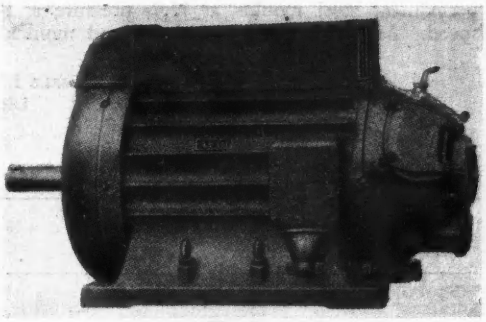


Fig. 4

A more elaborate cooling system is required by motors for continuous operation. Here the main generation of heat is produced in the rotor, and in consequence surface cooling alone is not sufficient. Fig. 5 shows a 52 KW, 1800 r.p.m. motor with positive circulation cooling: the air coming from the interior of the motor is cooled by cold water circulating in tubes. A similar type of motor was developed by the A.E.G., and is shown in Fig. 6. The cast steel casing is ribbed and the axial set off is kept fairly high. The fan for ventilation is fixed to the driving side of the unit and is covered by a bonnet. A separate ventilator circulates the air in the interior of the motor. An easy access to the collector is provided by felt tightened doors arranged at both sides of the casing.

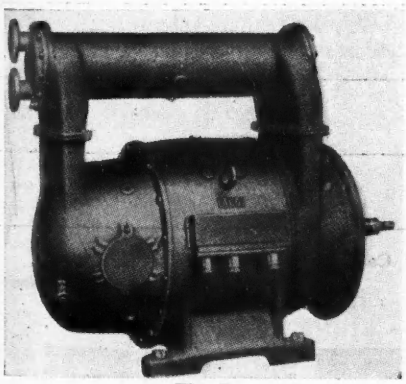


Fig. 5

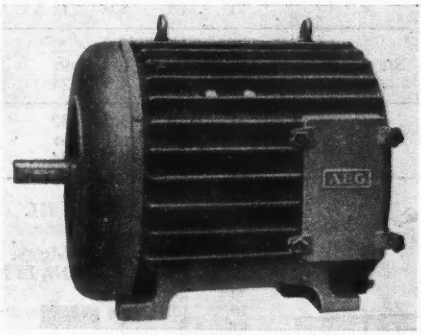


Fig. 6

FINISHED CASTING

By MARTIN STORCH. (From *Zeitschrift des VDI*, Vol. 21, No. 5, 25th January, 1941, pp. 119-125).

FINISHED casting is the process in which castings are produced with great precision so that little or no machining is needed. Finished castings, often referred to as spray castings or press cast-

ings, are obtained by pressing molten metal into permament steel moulds at high pressure and speed. Modern casting machinery and moulds make it possible that an order of less than 500 pieces can be made at economical costs, hence its increasing adaptation in practice.

TABLE I. **Lead Alloys.**

Type	Composition % Pb	Sn	Sb	Cu	Ult. tens. strength kg/mm²	Ult. elong. %	Brinell hardness	Density kg/dm³.
Sg Pb 97	96 to 98	—	2 to 4	—	5	20	9	11.1
Sg Pb 87	86 to 88	—	12 to 14	—	6	10	14	10.1
Sg Pb 85	84 to 86	4 to 6	9 to 11	—	7.5	8	18	9.8
Sg Pb 59	58 to 60	24 to 26	12 to 14	2.5 to 3.5	8	3	18	9.1
Sg Pb 46	45 to 47	39 to 41	11 to 13	1.5 to 2.5	8	4	17	8.6

TABLE II. **Tin Spray Castings.**

Type	Composition % Sn	Sb	Cu	Pb	U.T.S. kg/mm²	Ult. elong. %	Brinell Hardness	Density kg/dm³
Sg Sn 78	77 to 79	16 to 18	3.5 to 4.5	0 to 1.5	11.5	2.5	30	7.1
Sg Sn 75	74 to 76	16 to 18	4.5 to 5.5	2.5 to 3.5	10	1.8	30	7.2
Sg Sn 70	69 to 71	14 to 16	4.0 to 5.0	9.5 to 11.5	10	1.1	30	7.4
Sg Sn 59	59 to 61	12 to 14	3.5 to 4.5	22 to 24	9	1.7	28	7.9
Sg Sn 50	49 to 51	12 to 14	3.5 to 4.5	32 to 34	8	1.9	26	8.0

TABLE III. **Zinc Spray Castings.**

Type	Composition % Zn	Al	Cu	Mg, Si Ni, Li Mn	U.T.S. kg/mm²	Ult. elong. %	Brinell hardness	Density
Sg Zn—Al—Cu I	91 to 94	3.5 to 5	2.5 to 4		32 to 38	2.5 to 2	80 to 120	6.9
Sg Zn—Al—Cu II	93.4 to 95.75	3.5 to 4.1	0.75 to 2.5	less than 0.1 each	27 to 33	5 to 3	80 to 105	6.8
Sg Zn—Al	95.9 to 96.5	3.5 to 4.1	—		22 to 27	6 to 3	65 to 80	6.7

TABLE IV. **Light Metal Alloy Spray Casting.**

Type	Al	Cu	Ni	Mn	Si	Mg	Ult. str. kg/mm²	Ult. elong. %	Brinell hardness	Density kg/dm³
Sg Al—Cu	92 to 94	6 to 8	—	—	—	—	18 to 23	2 to 1.5	60 to 75	2.9
Sg Al—Cu—Si	90 to 92.5	6 to 8	—	—	1.5 to 2	—	20 to 25	1.5 to 1	70 to 90	2.9
Sg Al—Cu—Ni	92 to 94	4.5 to 6	1.5 to 2	—	—	—	19 to 24	2.6 to 1.6	70 to 90	2.7
Sg Al—Si	89.3 to 91.5	—	—	0.5 to 0.7	8 to 10	—	20 to 25	2.2 to 1.6	70 to 90	2.9
Sg Al—Si—Cu	90 to 94	2.5 to 4	—	—	3.5 to 6	—	20 to 24	2.2 to 1.8	60 to 70	2.8
Sg Al—Mg	88.5 to 96	—	—	0 to 0.8	0 to 1.2	4 to 9.5	20 to 24	2 to 1	70 to 90	2.6

	Al	Zn	Mn	Mg			
Sg Mg—Al—Zn	8 to 10	0.2 to 1	0.1 to 0.5	88.5 to 91.7	18 to 20	2 to 1	60 to 70	1.8

Materials.

Lead alloys (Table 1) containing antimony and tin for hardness and good casting properties respectively, are mainly used for type blocks and owing to their high specific weight for pendulums.

Tin alloys (Table 2) contain antimony and copper for hardness and economy respectively. The excellent casting quality of this alloy renders it suitable for high quality finished castings. Its main field of employment is in electric measuring instruments, electric meters, gas and speed meters, etc.

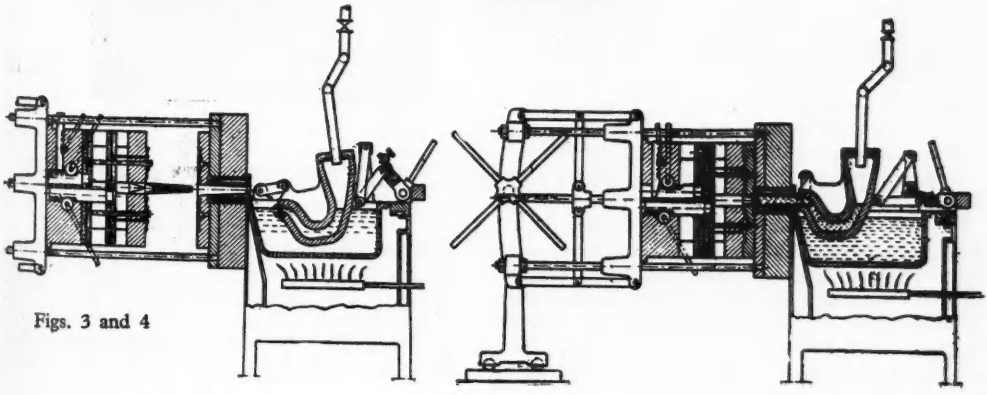
Zinc alloys (Table 3) are used for finished castings with or without addition of copper. The copper content increases the strength of the alloy, but this alloy is more subject to ageing than the copper free alloy.

Light metal alloys (Table 4). Aluminium alloys with a small addition of copper have high resistance to shock, while those containing silicon are used for thin castings. Al-Si, and Al-Mg are resistant to corrosion. Magnesium alloys with electron metal as the most important alloy of the series have a very low specific weight and possess excellent casting qualities.

Machines for Finished Castings.

For lead, tin and zinc alloys spraying machines are most suitable. Aluminium and magnesium alloys with higher melting temperatures require compressed air casting machines, while copper alloys necessitate brass press casting machines. The working principle of the spraying machine is shown in Figs. 1 and 2. A pressure chamber in the middle of the container is kept at the same

Figs. 1 and 2



Figs. 3 and 4

temperature as the molten metal. When the piston is at the O.D.C. metal can enter the spraying apparatus through small ports. During the return stroke the ports are closed, and the metal is pressed through the nozzle into the mould. The mould is then removed from the nozzle and the finished casting is forced out from the mould. The machines can be designed for full automatic operation. The moulds are made of carbon steel and are hardened. For zinc alloys special chromium-nickel steel or chromium vanadium steel moulds are used.

A compressed air casting apparatus, developed by the Döhler Casting Co., is illustrated in Figs. 3 and 4. A U-shaped pressure chamber with its open end reaching down into the molten metal can swing around a pivot. When it is filled with the metal it is pressed firmly against a nozzle connected to the mould. By opening the pressure valve the metal is forced into the mould by 30 atm. pressure. The pressure vessel is made of high grade special steel.

The press casting machines are characterised by a pressure chamber separated from the container and not heated. Much higher pressures are required than those used with heated pressure chambers. Figs. 5 to 10 illustrate the working principle of these types of machines. The metal enters the cylinder of the pressure chamber which has two opposed plungers; the lower plunger covers and uncovers an opening from the cylinder into the mould. When the upper plunger is pressed down this port is uncovered, and the metal is pressed into the mould, since the lower plunger is forced down against a spring pressure. During the return stroke of the upper plunger the spring forces the lower plunger upwards thus cropping the pipe from the finished casting, and finally forces it from the cylinder.

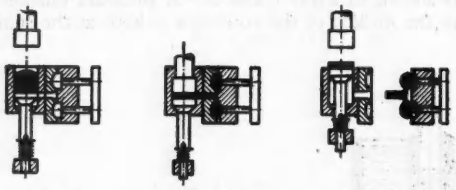


Fig. 5 Fig. 6 Fig. 7

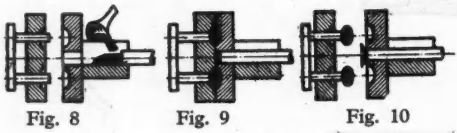
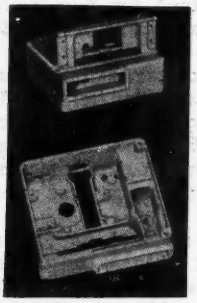


Fig. 8 Fig. 9 Fig. 10

Application.

The Photographic camera industry makes great use of finished castings. Nearly the whole of the apparatus is made from finished castings. Figs. 11 and 12 show a small film camera. The many small parts are replaced by a single casting.



Figs. 11 and 12

This results in greater rigidity and a reduction of weight of about 45%. For various measuring instruments made from finished castings aluminium alloy is used in place of tin alloys. The body of an instrument is shown in Fig. 13.

Fig. 13

LOW PRESSURE ELECTRIC BOILER, BROWN BOVERI SYSTEM

Low pressure electric boilers are built for voltages up to 500 Volt. and an output of 2000 kW. The electrode system is fixed on to the cover and the varying water level regulates the electric output which depends on the depth of immersion of the electrodes. A high water level corresponds to a heavy load, a low level to a light load, and, in this way, a variation of the load between 20% and 100% and sometimes even up to 130% of the normal load is secured. The boiler can be employed either for steam or hot water production. Although both types work on the same

principle, their regulation is different.

(1) Steam Boilers: Fig. 1 shows a cross section through a steam boiler and its electrical connections. The arrangement of the electrodes is as shown in the plan view. A cylindrical sheave embraces the electrodes and forms the starpoint of the system. A feed water tank is arranged next to the boiler, and it is fitted with a float to regulate the water flow. On the top of the tank a feed pump is placed and is driven by a three phase motor.

The steam pressure automatically regulates

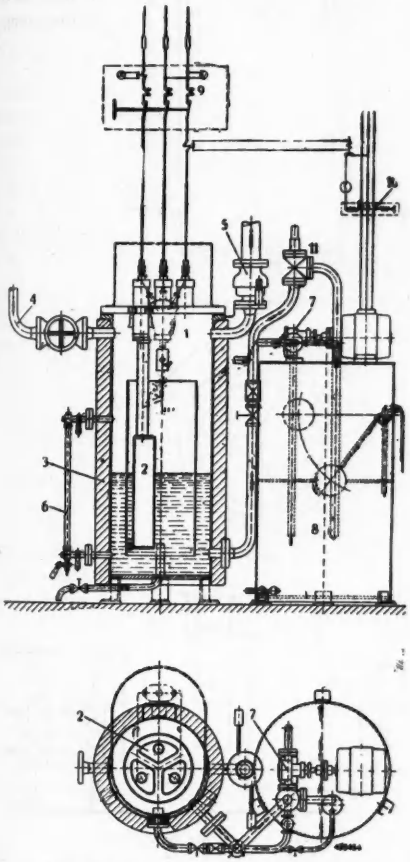


Fig. 1 (1) Electric Steam Boiler; (2) Electrodes; (3) Thermic Insulation; (4) Steam Pipes; (5) Safety Valve; (6) Water-level Indicator; (7) Feed Pump; (8) Feed Water Container; (9) Oil Switch with Volt-meter and Ammeter; (10) Oil Switch with Magnetic Operation for output regulation.

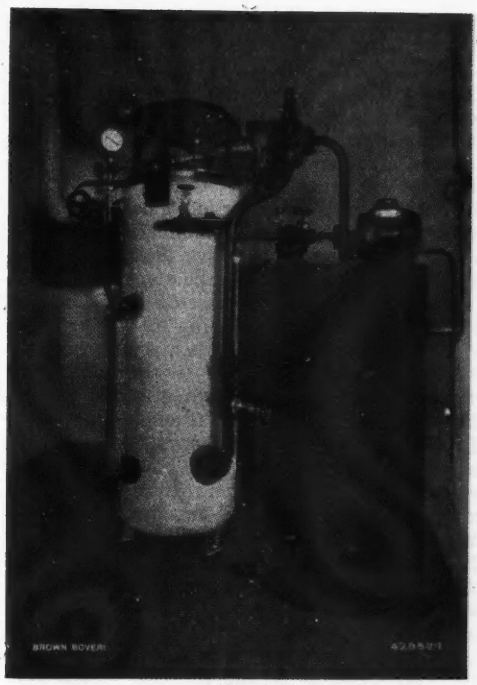


Fig. 2

the boiler feed. Between the feed pump and the boiler a leak-off connection to the feed tank is installed, into which an adjustable diaphragm is fitted. A considerable amount of water is running continuously through the diaphragm, which represents the standby load of the feed pump. Therefore even with variations of the feed water supply, the pressure in the discharge pipe of the pump changes only slightly. If the pressure in the boiler falls, the feeding main supplies more water into the boiler, thus increasing the water level, and, as a consequence, increasing the electrical output. The water is preheated before it enters the boiler. If the steam demand is decreasing the pressure is rising and a part of the pump output is discharged through the return main. As the diaphragm allows the discharge of a limited quantity of water only, according to the pressure in the boiler, a second discharge main with a gravity controlled overflow valve, is provided, which opens before the safety valve of the boiler.

The feed water tank offers the advantage that the hot water forced out from the boiler

pre-heats the feed water. Fig. 2 shows a complete plant of a low pressure electric boiler.

(2) Hot water boiler: The arrangement of the electrodes is similar to that of the steam boiler. An injecting nozzle is fitted into the middle of the cover to feed the water into the boiler in a fine spray, and the hot water is taken off at the lower end of the boiler. Fig. 3 shows the installation of the boiler into a central heating system. When the pump is running the flow of water is regulated by a valve (8). The boiler is kept under the pressure of the water column (7). Consequently the water is heated to the saturation temperature corresponding to this pressure which is independent of the temperature condition of the central heating. In the upper part of the boiler the rising steam is condensed by the water which is sprayed through the nozzle. If more steam is generated than that can be condensed, the pressure in the boiler rises, the water level is lowered, and consequently the energy input decreases until the energy input and the heat demand are in equilibrium. Fig. 4 shows the arrangement of a central heating plant, a coal and an electric boiler, the latter being connected in series with the heating system and the pump.

Often a temperature higher than the temperature corresponding to the pressure of the system is required. This higher temperature has a special significance for heating systems with heat accumulators. The scheme of such a system can be seen in Fig. 4.

The expansion vessel (2) is used for an accumulator and is connected to the boiler (1). The

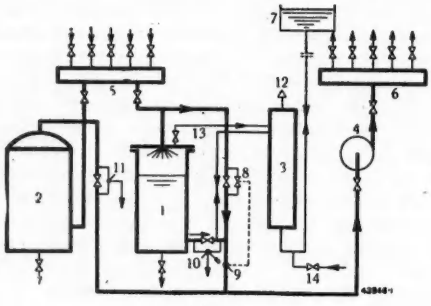


Fig. 3

(1) Electric Boiler; (2) Combustion Boiler; (3) Auxiliary Tank; (4) Pump; (5) Tank for Return Water; (6) Distributor; (7) Expansion Vessel; (8) Valve Regulator; (9) Thermostat Control; (10, 11) Safety Valve; (12) Air Ventil; (13) Air Inlet Pipe; (14) Feed Water Pipe.

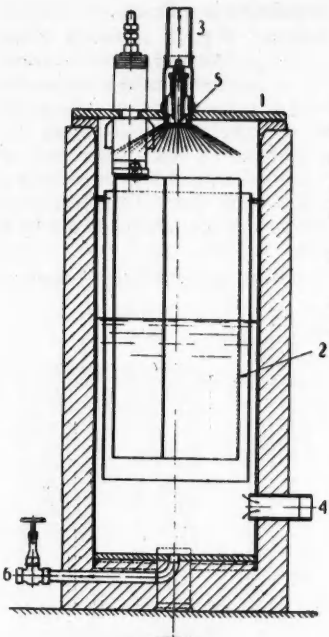
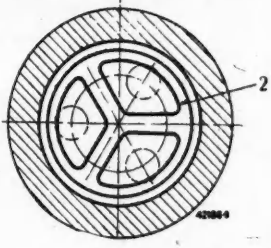


Fig. 4

(1) Electro Boiler;
(2) Electrodes;
(3) Warm Water Inlet;
(4) Hot Water Delivery;
(5) Injection nozzle;
(6) Emptying Valve.



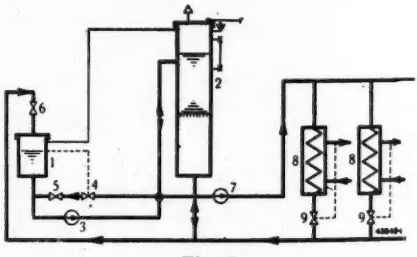


Fig. 5

pump (3) lifts the water from the boiler (1) into the expansion vessel (2), the water flowing from vessel (2) back into the boiler (1) through the regulating valve (4). With rising pressure valve (4) is closed, the level of the water in the boiler

falls and the input is decreased. The output of the boiler is regulated by the valve (6). The cold water in the lower part of the accumulator runs through valve (6) into the boiler. Here it is heated to boiling temperature and forced by a pump into the upper part of the accumulator. The circulation through the heating plant is effected by the pump (7). If the actual heat demand of the plant is higher than the boiler output the surplus is taken from the accumulator; if the accumulator is completely charged the temperature before the valve (6) rises and the input is automatically reduced to the actual demand of the plant.

LUBRICATION OF STATIONARY ENGINES

By Dipl. ING. ERICH THYSSEN, Hamburg. (From *Brennstoff-und Wärmewirtschaft*, Vol. 22, No. 3, 1940, pp. 36-38).

THE change over from liquid fuel to gas fuel in I. C. engines has many advantages, apart from the necessary war-time economy. Far reaching developments can be expected with stationary engines, where many problems arising with vehicles, such as constructional difficulties, accessory and gas producing apparatus, etc., are eliminated. A wide range of fuel is available for stationary engines, and the most suitable fuel can be selected.

Lubrication of the Driving Mechanism.

The lubricating oil is subjected to the most severe conditions in the cylinders, hence it is desirable to separate the lubrication system for the cylinders from that for the rest of the mechanism. This can be readily achieved with low speed stationary engines, especially if they are of the horizontal type. It is not suggested that different types of lubricant should be used, but that apart from the increase in the safety of working of the engines, a properly designed lubrication system will make full use of the lubricant.

Experience has shown that the circulating system is suitable. At the completion of the cycle the oil should be returned to the main reserve tank, to facilitate separation of the impurities after they have settled down. A suitable type of oil reservoir is shown in Fig. 1. The capacity should be sufficient to avoid having to circulate the oil more than eight or ten times per hour, in order to give time for separation of impurities. If the oil returning from the cylinders is collected in a separate container and is conveyed separately, it will not affect the lubricant used for the bearing. If separation of the lubricating systems is not carried out, the lubricant passing to the bearings contains products of burning, unburnt fuel particles, acids, and various substances resulting from the excessive heat to which the lubricant is subjected in the cylinders.

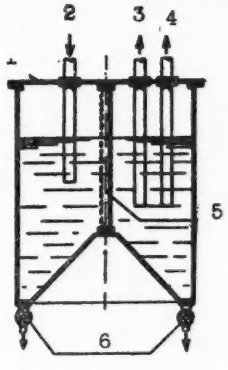


Fig. 1
(1) Hole through Cover.
(2) Oil Return Pipe.
(3) Auxiliary Pump.
(4) Main Pump.
(5) Removable sieve (50 mesh).
(6) Sludge Drain Cock.

Lubrication of Cylinders.

The lubricant has to form a continuous layer of oil film on the surface of the cylinder and piston, and also helps to provide a packing. It is important not only to choose a suitable lubricant, but also to arrange for a uniform distribution of the oil. Excess lubricant must not be allowed to collect between the rings on the piston as this would lead ultimately to jamming of the rings. These rings play an important part in the distribution of the lubricant, hence jamming of the rings would stop a proper oil distribution. The appropriate admission of the lubricant regarding quantity and place has to be considered carefully in relation to the working conditions of the engine. The writer suggests that oil should be admitted to the cylinder at points near to each other, and that efficient lubrication can be obtained by introducing the oil along channels inclined to the path of the piston travel.

If the number of points where lubricant is admitted is insufficient, or if the viscosity of

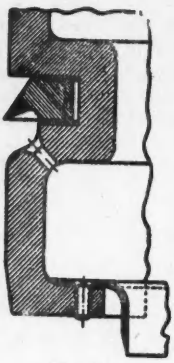


Fig. 2

the lubricant is too high, the continuous film will not form, but more or less dry spots will appear on the surface to be lubricated. Also, part of the oil would remain between the rings for a comparatively longer time, and thus be exposed to the high temperatures. Local excesses of lubrication can be caused by unsuitable oil wiping rings and poor oil conveying channels. A suitable and efficient oil wiping ring construction is shown in Fig. 2.

The Influence of the Type of Fuel on the Lubrication.

The formation of residue in the combustion chamber, and the wear and tear of the piston rings, depend considerably on the type of gaseous fuel used. The writer suggests that fuels with a high sulphur content should be avoided, as the thin oil film in the hotter parts of the engine cannot give good protection against the action of SO_2, and that the only method of protection is to check the sulphur content of the fuel. He suggests that the least satisfactory gas fuel would be that obtained from mineral coal and brown coal, that coke gas would be more satisfactory, and that the least sulphur content is in the butane, propane, and methane gases.

Other factors must also be considered when choosing the lubricant. Multi-molecular (C_n H_n) hydrocarbons can easily condense on cooler surfaces and hence lead to a formation of residue on the valves, valve seatings, and rings. Owing to their high adhesive force they will settle down on dry or semi-dry surfaces (which are not covered with an oil film), and, naturally, give rise to lubrication troubles. Some protection against this is to use lubricant with small viscosity. But it is more satisfactory to increase the number of points of oil admission and carefully controlling the oil distribution.

The great variation in the H_2 and CO contents of the fuel give rise to greatly varying calorific values, and consequently to a variation in cylinder surface temperature. An oil with flash point 210° C. and viscosity 6° Engler at 50° C. free from asphalt has proved satisfactory for general conditions. Badly refined oils and distillates are unsatisfactory, especially for high speed engines.

AIR CONDITIONING OF RAILWAY COACHES

By F. ROEDLER. (From *Zeitschrift des VDI*, Vol. 21, No. 5, 25th January, 1941, pp. 132-133).

LONG distance journeys result in an increasing dissipation of nervous energy of the passenger, often twice as much as that required by the human body at complete rest. The result is a feeling of fatigue by the passenger. The air-conditioning equipment of the coach has a great influence on the comfort of the passenger. A reduction in the duration of the journey by increasing operating speeds is a step in traffic hygiene.

The difficulty of air-conditioning in railway coaches is the limited space of from 1 m^3 per head in 3rd class coaches to 2.6 m^3 in 1st class coaches. The problem of maintaining a uniform temperature in the coach is easier to solve than the ventilation question. Open windows lead to draught and considerably increases the air resistance of the train. Special arrangements taking the form of suction and pressure ventilator are therefore indispensable.

To compare the efficiency of the air-conditioning a Katathermometer has been developed. The measured " dry Kata number " gives the cooling effect of the atmosphere. The actual value depends on the temperature and also on the flow of air. The ratio of air temperature T and Kata number A gives the correlation between Kata number and the comfort of the passenger. It is termed " comfort index " and table L gives information regarding this characteristic.

" D " class cars fabricated in steel, built in 1929-30, employing low pressure circulation heating with automatic regulation for each compartment, were investigated. When the windows, flaps, and roof ventilators were closed the Comfort index was between 3.3 and 5.2 and the temperature was constant. The relative humidity averaged 60% and was, therefore, pleasant.

The effect of ventilation on the atmosphere in a motor coach was investigated. With no ventilation the comfort index was 5.0; this could be reduced to 4.3 by the use of suitable fans, and to 3.9 by using natural draught. To ensure the

necessity for artificial air-conditioning only on hot summer days, special callottes taking the shape of perforated spherical openings were fitted into the roof (Fig. 1).

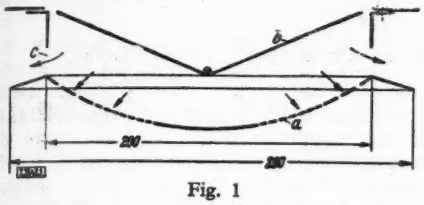


Fig. 1

Aeration of the seats is only bearable at room temperature from 20° upwards, at lower temperatures the perforated callotte was fitted with a pair of flaps. It appears that at about 20° a critical temperature exists to which is correlated an air-speed of 0.3 m/sec.

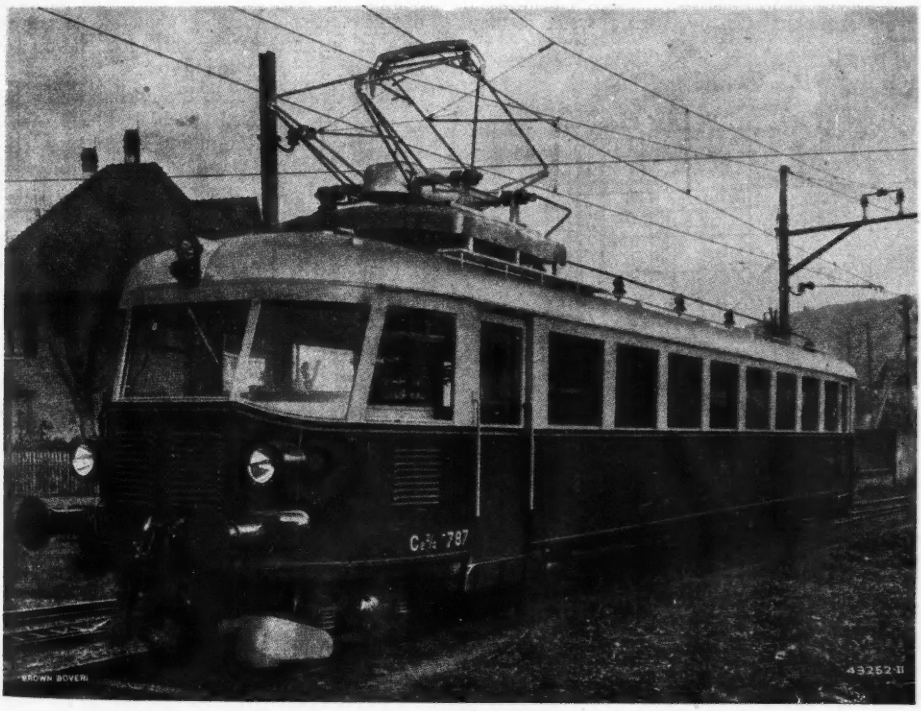
TABLE I.

		Stationary Air	Velocity of Airflow in m/sec. 0.1	1.2	0.4	0.6
Upper limit	t_L	22.0	22.6	23.75	25.3	26.2
of comfort	A	4.0	4.5	4.8	5.1	5.3
(warm)	$B = t_{L/A}$	5.5	5.0	5.0	5.0	5.0
Max. comfort	t_L	18.8	19.0	19.5	21.0	22.0
	A	5.0	5.7	6.4	7.0	7.3
	$B = t_{L/A}$	3.75	3.35	3.0	3.0	3.0
Lower limit	t_L	15.9	16.0	16.3	17.4	18.4
of comfort	A	6.0	6.7	7.6	8.7	9.2
(cold)	$B = t_{L/A}$	2.65	2.4	2.15	2.0	2.0

LIGHT MOTOR COACH Ce 2/4 Nr. 787 OF THE BERNER ALPENBAHN GESELLSCHAFT

(From *Brown Boveri Mitteilungen*, March, 1940).

THE first light motor coach delivered to the Schweizerische Bundesbahn in May, 1935, had covered over 75,000 km. when the new coach, No. 787, came into operation. Its maximum speed is 90 km/hr and is able to draw one or more supplementary cars. It was intended to use this



coach on the very tortuous and heavily graded Bern-Schwarzenburg line. For these most unfavorable track conditions the motor coach, No. 787, had to be equipped with bogies, type Schweizerische Industriegesellschaft, suitable for sharp curves. In spite of the comparatively large wheel base of the bogie, 3.4 m., this coach runs very smoothly owing to the floating axles employed which are capable of a limited radial movement.

Each bogie is provided with its own driving motor, the motors being connected in parallel. For speed regulation a rheostat with 10 studs and an electrical short circuit brake with not less than 50 braking positions is provided, resulting in a smooth acceleration and braking. The electrical apparatus was arranged to be as simple as possible in view of the fact that the coach is controlled by only one attendant. A simple contact rheostat governs the speed during the journey. A handwheel covers a switching angle of 50° of the electrical brake, and is connected to the Brown Boveri safety mechanism.

Particulars of motor coach No. 787.

Maximum speed	90 km/hr
Motor rating (at 50 km/hr)	280 H.P.
Seating accommodation	65
Standing passengers	50
Weight of chassis	24 tons
Weight of electrical equipment ..	8.5 tons
Tare	32.5 tons
Driving wheel diam.	800 mm.
Gear ratio	1/3.27

THE NEW DE-ACIDULATING PLANT IN THE WATER-WORKS FRANKFURT a.M.

(From *Zeitschrift des V.D.I.*, Vol. 84, No. 5, February, 1940).

THE protection of the pipe lines of the domestic water system of Frankfurt a.M. and of the pipe lines between the pumping stations and the reservoirs from the corrosive natural water in the district required the erection of water treatment plants in the station of Hinkelstein, Goldstein, Forsthaus, and Hattersheim. The existing but obsolete marble filtering plant at Sachsenhausen was of insufficient capacity and did not effectively de-acidulate the water.

The daily output of the normal load station of Henkelstein is 16,000 to 24,000 m³, its temporary hardness is 1.3°, the pH value being of the order of 6.0, and the natural water contains 33 mg/1 of CO_2 (carbon anhydride).

The lime de-acidulating plant type Bücher, Fig. 1, is of the open

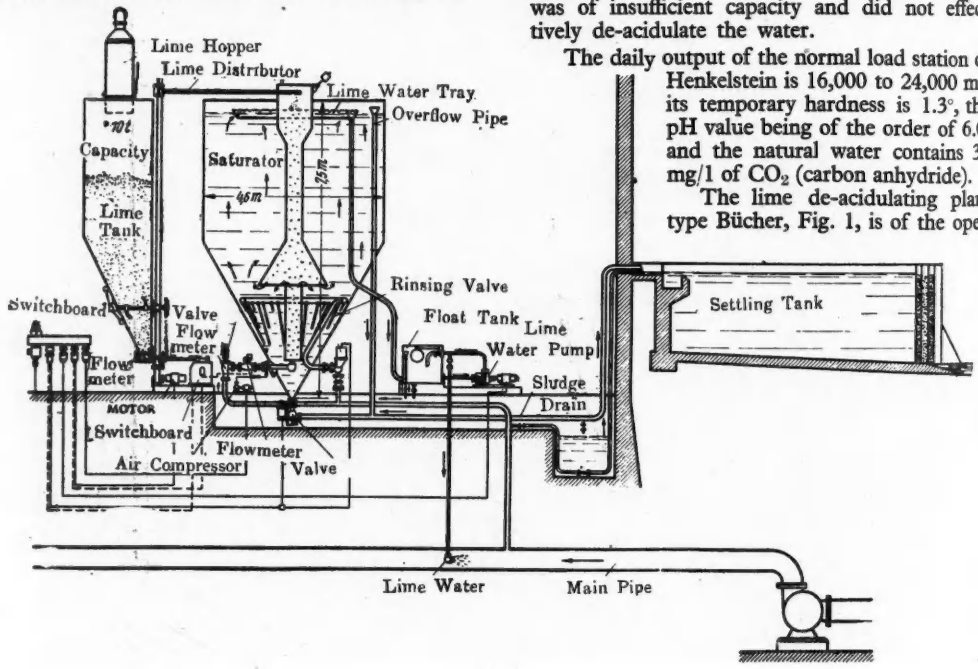


Fig 1

type and is automatic in operation, completely treating the water by removing all the dissolved CO_2, increasing the pH value to 8.2 and the temporary hardness to 3.3°. Two plants were constructed, each of which is capable of de-acidulating 16.000 m^3 of water per day, by supplying 325 m^3 of saturated lime water, temporary hardness 12.6°. The actual quantity of lime involved is 34.25 gm/m^3.

At the peak load pumping station Goldstein, an enclosed lime de-acidulating plant, type Balcke-Riwag was installed, and was arranged to respond automatically to a variable output of from 16.000 to 20.000 m^3 per day. The water containing 35 mg/1 free CO_2, pH value 5.85 and temporary hardness 0.9°, after treatment is completely free of CO_2 has a pH value of 8.1, and a temporary hardness 3.1°.

To produce the required circulation of water through the lime saturators, a nozzle is fitted into the lifting main of 600 mm. diam. Suction and discharge from the saturators is taken from tappings at the entrance and throat of the nozzle. In this way when the demand is increasing, the circulation head is increased and automatically more lime water is discharged into the main. Four lime saturators are employed, each filled with 600 kg of lime which is sufficient to saturate 20.000 m^3 of water. The concentration of lime is 37.44 gm/1, this figure including the losses when cleaning and recharging the plant.

At the peak load station Forsthaus with at capacity from 4000 to 7800 m^3/day, a covered plant working automatically on the Magno system has been erected. The natural water with about 30 mg/1 free CO_2, a pH value of 6.3, and a temporary hardness number of 1.7° is treated in a filter with a capacity of 42 tons of Magno, 0.5 to 3.0 mm. grain size so that it is supplied to the domestic system with a pH value of 7.7, a temporary hardness of 4.0° and only 1 to 2 mg/1 of free CO_2.

The two filters employed are 4.8 m. high and 3 m. diam., and are rinsed once a week with water and compressed air. At the base of each filter 350 Magno filter nozzles are used.

The normal load pump station at Hattersheim 32.000 to 48.000 m^3/day, the water has to be aerated and sprayed to avoid an increase in temporary hardness after treatment, as the natural water contains 55.0 mg/1 of free carbonic acid, has a temporary hardness of 13.1° and its pH value is 7.0. The spraying arrangement consists of two towers having a surface of 225 m^2, and each fitted with 216 nozzles. Each tower has three ventilators, able to pass 1.2 m^3/sec. of air which is required to aerate the water. The Schlick nozzle discharges 7.5 m^3/h when the available head is 3 m. and 9 m^3/h at full load the head then required being 5 m., the height of the spray varies from 1.2 to 1.5 m. The water after treatment by this plant contains 24 mg/1 free CO_2, its hardness is kept at its original value of 3.1° and the pH value at 7.5.

Whereas the Hattersheim and Forsthaus plants are automatic, the Hinkelstein and Goldstein plants require attendance for charging the saturators and for supervision. In the latter

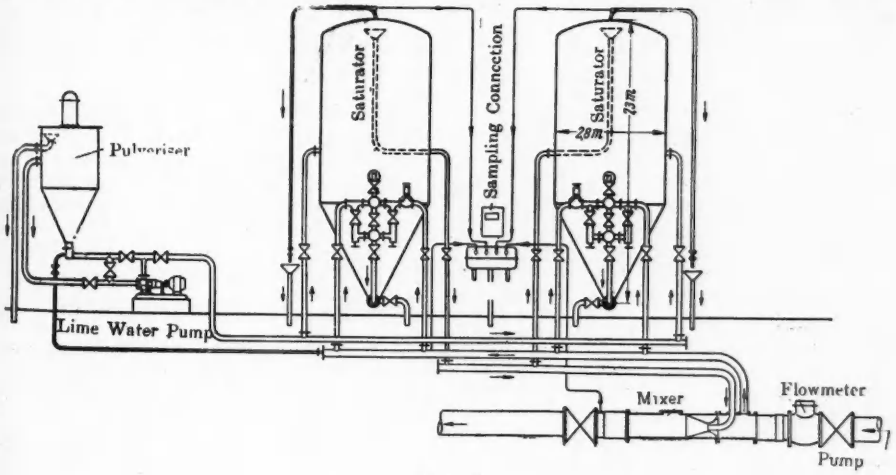


Fig. 2

plants, one saturator has to be replenished daily, involving the labour of two men for two hours. The operation of all the plants however is effected from the laboratory by daily checks on the degree of de-acidulation and lime concentration. All the plants maintain the desired degree of treatment except the plant working on the Magno system.

THE PROGRESS OF DIFFUSION IN CLAD ALUMINIUM-COPPER-MAGNESIUM ALLOYS

By H. J. SEEMANN and M. DUDEK. (From *Aluminium*, Vol. 22, Oct., 1940, pp. 521-524).

DIFFUSION of alloying elements from the core material into the coating occurs in the course of the manufacture and heat treatment of duralumin-type alloys clad with high purity aluminium, commercial purity aluminium or aluminium-manganese-magnesium-silicon alloy. The nature of the coating layer influences the effect of such diffusion. The clad layers tested had a thickness of about 4 to 6% of the total thickness, and the progress of diffusion was studied at different temperatures with different annealing times.

The diffusion of copper into the commercially pure aluminium and more markedly in the highly pure aluminium takes place mainly at the grain boundaries, while with the alloy cladding a common diffusion front for grain boundary and grain interior is formed. The curves obtained for the depth of penetration of copper as a function of the duration of annealing temperature, can be used for determining the optimum heat treatment to obtain a definite condition of diffusion.

The grain boundary diffusion in the two types of aluminium cladding increases the corrosion resistance of the various layers. The accumulation of copper in the grain boundaries may give rise to cracking and fracturing of the layers. Inter-crystalline corrosion takes place where these cracks penetrate to the core material, if the alloy is exposed to corrosive action. This harmful effect of copper diffusion could not be observed in clad layers of the aluminium-manganese-magnesium-silicon alloy.

FORMATION OF "PRESSURE-FOLDING" CRACKS IN THE FREE-TO-SPREAD ROLLING OF STEEL

By A. POMP and W. LUEG. (From Mitteilungen d. Kaiser-Wilhelm Inst. f. Eisenforschung, Vol. 22, No. 16, 1940, pp. 241-254).

IF spreading of the material hot rolled is not prevented "pressure-folding" cracks may occur owing to the roughness starting at the sides of the work. These cracks are formed during an unfavourable upsetting when the work undergoes subsequent deformation.

The following materials were investigated: (a) carbon steel with 0.88% C; (b) Chromium-moly steel with 0.36 C, 1.05 Cr, and 0.17 Mo; (c) nickel carburizing steel with 0.13% C and 3.47 Ni; (d) Stainless cutlery steel with 0.41% C, 13.6 Cr. Rolling took place at about 1300 to 2200° C, and magnetic powder method and hot etching were employed for surface testing.

It was found that with increasing rolling temperature the surface roughness is increasing. The smoothest surface was obtained with the carbon steel, then came the chromium-molybdenum steel, then the nickel steel. The cutlery steel had a smooth surface, but developed many longitudinal cracks when rolled at 1800 to 2000°C. When deep-etched this last steel showed many pickling cracks, probably due to the shearing stresses produced by the flow of metal. The nickel steel showed the markest tendency to form pressure folds.

In the appendix surface defects are described more fully, especially pickling cracks in the cutlery steel, and the method of deep etching causing these cracks is described. Too long etching is not the cause of these cracks, because they occur even after etching periods of 5 min.

NEW DAM FOR THE KLINGNAU POWER STATION

By E. ALTSCHUL. (From *Brown Boveri Mitteilungen*, Vol. 27, September, 1940).

THE Klingnau power station has been recently provided with a new dam. The four sluices each of 30 m. are closed by double (under and upper) sluice gates (Fig. 1). To allow for varying water conditions each sluice gate is independently driven by winch gear. Terminal switches prevent overrun of the extreme positions of the gates.

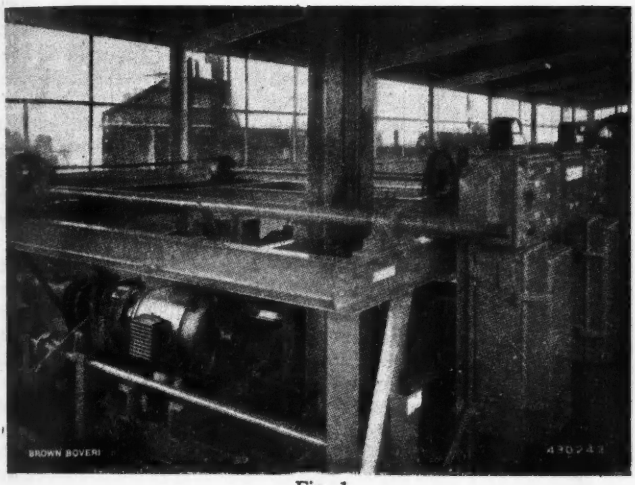


Fig. 1

Fig. 2 shows the layout of the operating mechanism placed above one of the ten weir openings. The two lateral driving gears with the chain driving drum and the first intermediate gear can be seen very distinctly. In the centre are the winch motors and transmission gears, the speed reduction gears, and the terminal stop mechanism. For lifting the gates two strong chains are used. A winding arrangement and a chain guide prevents any possibility of the chains binding. During the lifting of the gates the chains are automatically guided on to the grooves in the

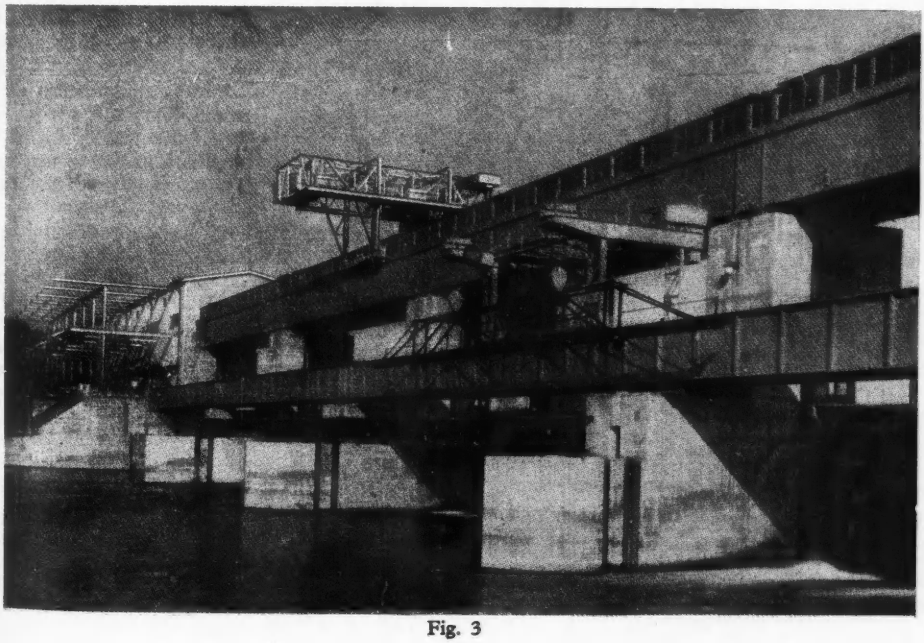
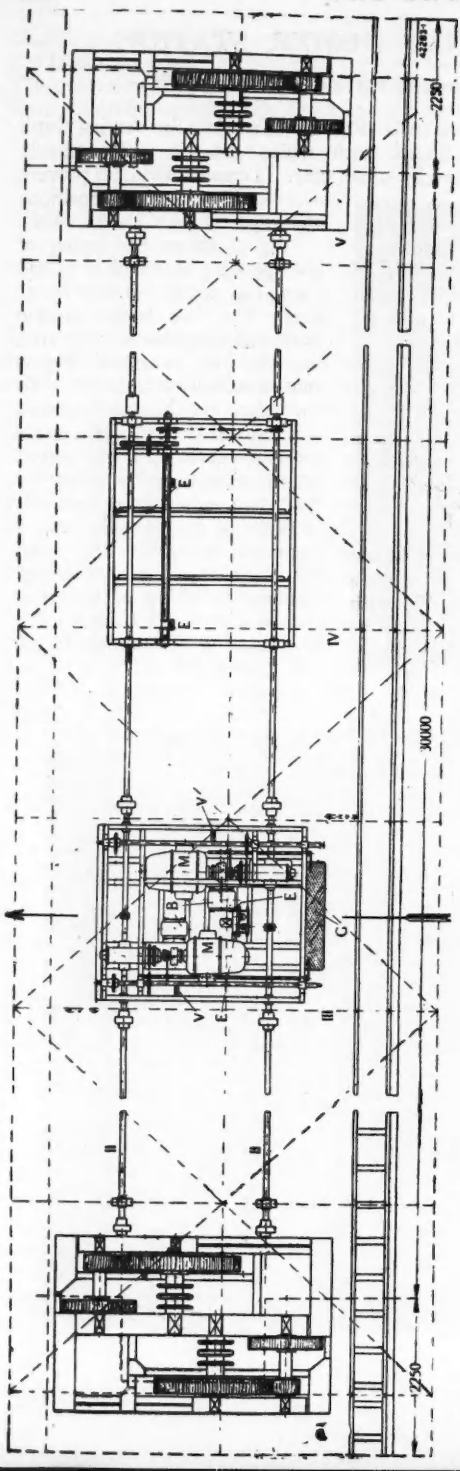


Fig. 3



drum. The tractive force of the winding gears is 180 tons for the under sluice gate and 115 tons for the upper sluice gate. Each motor drives the first reduction gear through a slipping clutch. The fast running reduction gear is a worm gear of modern construction with steel worm and bronze wheel, equipped with ball bearings and running in a totally enclosed cast iron, oil-filled casing. An electro-magnetic brake stops the motor when switched off. This brake is locked in its rest position by hold-off springs and opened by a brake lifting magnet. In the event of a failure of the supply, the brake acts automatically and stops the drive. In an emergency, a hand drive is provided to move the sluice gates without the motor. An indicator fixed on the wind gear bridge shows the actual lift and the mutual position of the two sluice gates. The lifting speed of the plates is 0.3 m/min. As a consequence of the different loads and of the resulting unequal revolutions of the synchronous motors, a slow leading of one or the other gate is possible. A locking device operated by a differential gear is provided to prevent the gates opening. This device is operated when the terminal positions are reached and stops the winch motors. The electrical equipment using three phase current at 380 volts, 50 cycles consists of 8 synchronous motors with special short circuit rotors, giving a high starting torque for a relatively small starting current. The four upper gates are each driven by a motor with an output of 17 KW in 30 minutes, the lower gates by motors of 20 KW/30 min. output. Each winding gear group has a separate cast iron enclosed switch containing in its lower part the protection for the motor, the ratchet motion, and in the upper part push buttons for lifting, lowering and stopping the upper and lower sluice gates (Fig. 3).

Each gate can be operated by simply pressing the button. Parallel to these push buttons, other buttons in the central station enabling remote control of the gates are also provided. At the end of the bridge, near the central station, is a low voltage distributing plant with the necessary fuses and switches. The electric installation is completed by a float control which automatically lowers the upper sluice gate should the water level rise.

Fig. 2

(B) Brake release magnet (E) Terminal switch (G) Control panel (M) Motor (V) Interlock, hand operated (I) Reduction gear (II) Transmission shafts (III) Operating mechanism (IV) Differential gear switch mechanism.

INJECTION LAG IN A JERK-PUMP FUEL INJECTION SYSTEM

By G. W. BAIERLEIN. (From *Diesel Power*, Vol. 19, Nos. 2 and 3, pp. 126 and cont., and pp. 209 and cont.).

FOR the perfect functioning of a Diesel engine it is of great importance that injection of the fuel begins at a certain point in the cycle, over the speed range. When the injection pump and the nozzle are connected by a length of piping, a time interval, the "injection lag," is created between the beginning of the fuel delivery by the injection pump and the beginning of injection at the nozzle. This injection lag depends on many factors, the kind and magnitude of which as well as the processes in the pressure piping in general, were investigated in the Research Laboratory of the American Bosch Co.

For the purpose of investigation a standard Bosch injection pump was used. The spray nozzle and its holder, employed in the tests, differed from the standard units only in that the fuel duct in the holder was arranged in such a way that the fuel would flow to the nozzle in as straight a path as possible.

The pressure piping and its connections between injection pump and nozzle were so arranged that the piping formed a straight path. In this manner disturbances were eliminated.

The movement of the pump plunger creates pressure and velocity waves in the pressure piping which travel with acoustic velocity. The acoustic velocity of fuel oil varies between 4750 and 4900 ft./sec. The waves are completely reflected at the nozzle as long as the latter is closed. This wave reflection may repeat itself at the injection pump and continue for some time. The hydrodynamic condition of a fluid element in a given time interval, then, is determined by the algebraic sum of the two functions, pressure and velocity. Fig. 1 shows schematically the travel of velocity and pressure wave at uniformly increasing plunger velocity; at the left for any point in the pressure piping prior to reflection, and at the right for the reflection of waves at the nozzle.

The magnitude of the velocity waves may be expressed as

$$V = C.\, v_s.\, p,$$

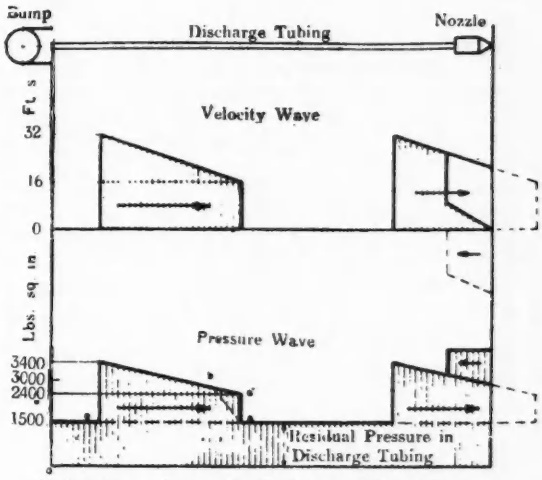
where V is the velocity of the fuel in the tubing in ft./sec., p is the pressure rise in the pressure piping in lb./sq. in., and C is the compressibility of the fuel, approximately 3.5×10^{-6} sq. in./lb., and v_s is the acoustic velocity of fuel oil.

Principally the injection lag may be considered as being composed of two sections: (a) the time it takes for the first pressure and velocity wave to travel from the pump to the nozzle; (b) the time which elapses after arrival of the first wave at the nozzle until the nozzle valve is lifted.

The first of these corresponds to the acoustic velocity of the fuel oil. Furthermore it was found that with a sufficiently high modulus of elasticity the elasticity of piping has no effect on the time interval (a).

But the acoustic velocity of the pressure wave is attained only when there exists a certain residual pressure in the discharge tubing. If the residual pressure drops below atmospheric the acoustic velocity will be smaller, decreasing with a further lowering of the pressure.

The pressure and velocity waves do not progress with vertical "wave fronts" (a-a' in Fig. 1) as is expected from the equation $V = C.v_s.p$, but the pressure rises gradually (see a-b, Fig. 1). The greater the fuel velocity at the beginning of delivery the steeper the pressure rise. The greater pressure rise at the head of



Left: Any point in the discharge tubing prior to reflection of the wave.
Right: Reflection of the wave at the nozzle.

Fig. 1

the wave is explained by the compressibility of fuel and the fact that the fuel velocity in the pressure piping cannot increase instantaneously. Consequently the time interval between arrival of the pressure wave and the lifting of the nozzle valve in practice, is always greater than in theory.

Factors Influencing the Injection Lag.

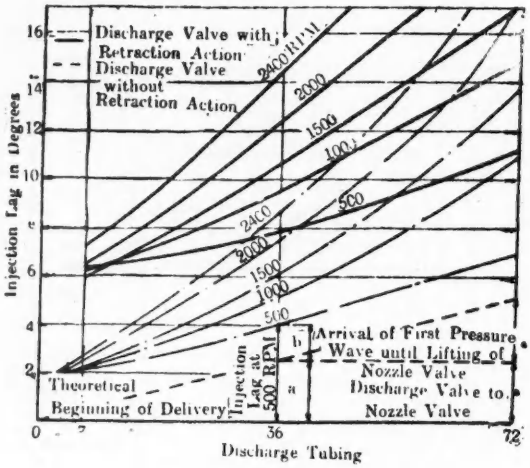
Investigations were carried out:

(1) With pressure piping of various lengths.
(2) For various nozzle openings.
(3) With three different diam. plungers.
(4) With piping of various inside diams.
(5) With increased and decreased flow areas, bends and corners in the pressure piping and piping of various materials.
(6) For various pressure differentials between closing and nozzle release pressure.

1. Effect of Length of Pressure Piping.

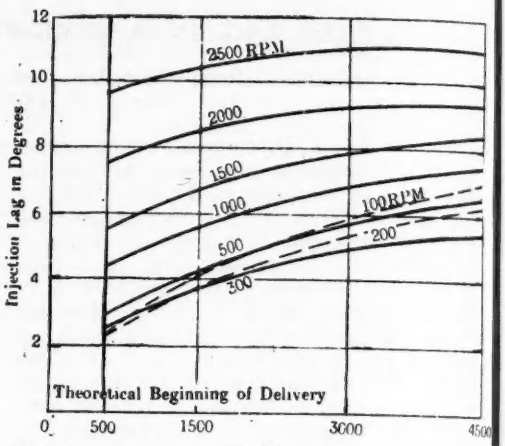
Fig. 2 shows the effect of the length of pressure piping on the injection lag. The injection lags in dependance of the length of the discharge tubing are illustrated for 500, 1000, 1500, 2000, and 2500 r.p.m. The higher the speed the greater the injection lag.

The distances between the curves for 500 and 1000 as well as between 1000 and 1500 r.p.m. and so on are not exactly alike, as the closing pressure in the pressure piping is somewhat different at different speeds.



8 mm. dia. plunger.
$\frac{1}{4}$" O.D. × $\frac{3}{32}$" I.D. discharge tubing.
1500 lbs./sq. in. nozzle opening pressure.
— — — Arrival of the first pressure wave at the nozzle at 500 r.p.m.

Fig. 2



Nozzle opening pressure in lbs./sq. in.
8 mm. DIA. plunger.
$\frac{1}{4}$" O.D. × $\frac{3}{32}$ I.D. × 36" long discharge tubing.
Discharge valve *without* refraction action.

Fig. 3

When the injection pump is equipped with "unloading" valve the injection lag becomes greater; due to the retraction and pressure release action of the valve the residual pressure may drop below atmospheric and, therefore, the acoustic velocity of the pressure wave will be lower.

2. Effect of Nozzle Opening Pressure.

That the injection lag increases with rising nozzle release pressure is shown in Fig. 3. The time interval for the pressure rise from arrival of the first pressure wave at the nozzle valve until the lifting of the valve increases between 500 and 4500 lb./sq. in. nozzle release pressure, because the difference between closing pressure and nozzle release pressure increases with increase in nozzle opening pressure.

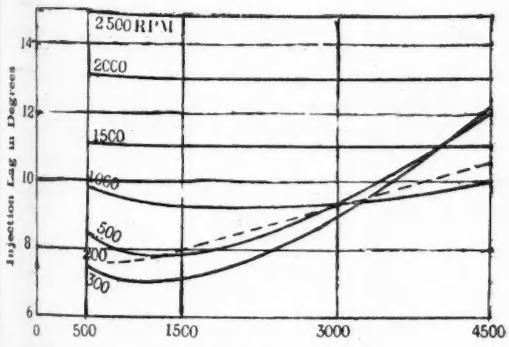
It will be seen that below 300 r.p.m. the injection lag increases again. The same trend, only for correspondingly higher values of the injection lag, is observed in the curves of Fig. 4, which, for otherwise identical conditions, are for the "unloading" valve. Here, however, the increase in the injection lag occurs at 500 revs. The explanation for it follows from Fig. 5. Here are illustrated the nozzle valve lift diagrams during the beginning of injection in relation to camshaft degrees for speeds from 1500 to 600 r.p.m. For 150 to 250 r.p.m. the injection lag

increases and the nozzle valve continuously remains open during the injection. At 300 r.p.m. however, due to the increasing fuel velocity, the stronger pressure wave is in evidence and the beginning of injection occurs earlier.

At the beginning of the lift of the nozzle valve the velocity wave is still too weak to create sufficient velocity for the flow area opened up by the nozzle valve, with the result that at the nozzle, pressure must be converted into velocity. This weakens the pressure wave so much that the nozzle valve again drops on its seat and closes prior to the beginning of the fuel injection. With increase in speed the reseating and closing of the valve gradually stops beyond 350 r.p.m. The greater the speed the more the loops in the nozzle valve lift diagrams due to the reseating of the valve, disappear, and at 600 r.p.m. no loop is noticeable.

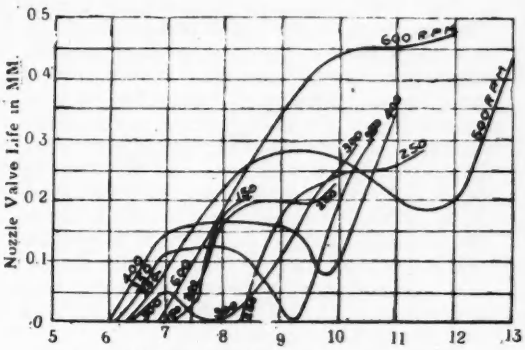
The injection lag between 200 and 2000 r.p.m. at 4500 lb./sq. in. nozzle release pressure varies only by approx. 2.5 degrees (Fig. 4). The nearly constant beginning of injection between 500 and 4500 lb./sq. in. for 1200 to 2500 r.p.m., too, is conspicuous; in the case of the discharge valve without retraction action there occur variations in the beginning of injection of about 2 to 3 degrees. An explanation in this case is offered by the variation of the acoustic velocity of the pressure waves at residual pressures below atmospheric.

Since the unloading volume of the discharge valve is constant and, therefore, for identical speeds the drop in line pressure at the end of injection remains identical, the residual pressure,



Nozzle opening pressure in lbs./sq. in.
8 mm. DIA. plunger.
$\frac{1}{4}$" O.D. × $\frac{3}{32}$" I.D. × 36" long discharge tubing.
Discharge valve *with* refraction action.

Fig. 4



Pump camshaft degrees.
8 mm. DIA. plunger.
$\frac{1}{4}$" O.D. × $\frac{3}{32}$" I.D. Discharge tubing.
1500 lbs./sq. in. nozzle opening pressure.
Discharge valve *with* refraction action.

Fig. 5

too, is higher at higher nozzle opening pressure. At 2500 r.p.m., for instance, the residual pressure for a nozzle release pressure of 500 lb./sq. in. is less than atmospheric; for 4500 lb./sq. in. it is 70 to 150 lb./sq. in. The acoustic velocities in these cases are 2600 and 4900 ft./s. respectively. This shortening of the time interval required for the waves to travel from pump to the nozzle compensates for the lag which the beginning of injection suffers in that the pressure at the nozzle valve must rise to 4500 instead of to 500 lb./sq. in. This result applies only to speeds above about 800 r.p.m.; below this speed the time which elapses for the pressure rise at the nozzle valve after arrival of the first pressure wave outweighs all other influences.

3. Effect of Fuel Velocity.

The fuel velocity may be varied either by raising the speed or at constant speed by variation of the pump plunger diam. From Fig. 6 the effect of varying the plunger diam. is the same as that of varying the speed of the pump (Fig. 5). For the 6 mm. diam. plunger, that is, the smallest fuel velocity, the injection lags at identical speeds are considerably greater than for the larger diam. plungers.

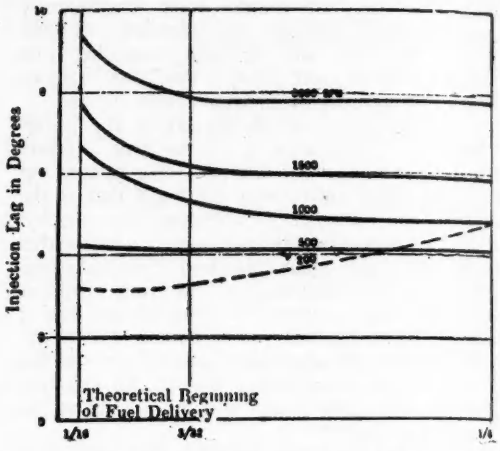
The acoustic velocity is not influenced by the fuel velocity. The acoustic velocity is practically constant, hence the portion of (a) of the injection lag (see Fig. 2) is not affected by changes in the pressure piping flow area. Only the portion (b) is subject to certain variations.

The smaller the cross sectional flow area of the pressure piping the higher is the fuel velocity at a given speed. Therefore stronger pressure and velocity waves may occur. Due to very strong waves considerably more fuel can be injected during the closing period of the nozzle valve than corresponds to the release pressure of the nozzle. Thus it happens that for identical speeds and nozzle release pressures, the pressure in the piping at the end of the injection process may be only 15 to 30 lb./sq. in. in a pressure pipe of 1/16th in. internal diam., despite the use of a discharge valve without unloading action, as compared with 850 to 1000 lb./sq. in. in a tubing of 1/8th in. internal diam.

Below 300 pump r.p.m. the closing pressures are not much different for all sizes of discharge tubings due to the prevailing low fuel velocity.

In the case of pressure piping with sharp bends or corners no differences in the injection lag could be detected. This very reassuring result holds true only if the flow area of the discharge tubing is maintained constant. It is therefore advisable to avoid as much as possible variations in the flow area, except at the beginning or end of the pipe, for these variations show a uniform effect as is indicated in Fig. 8.

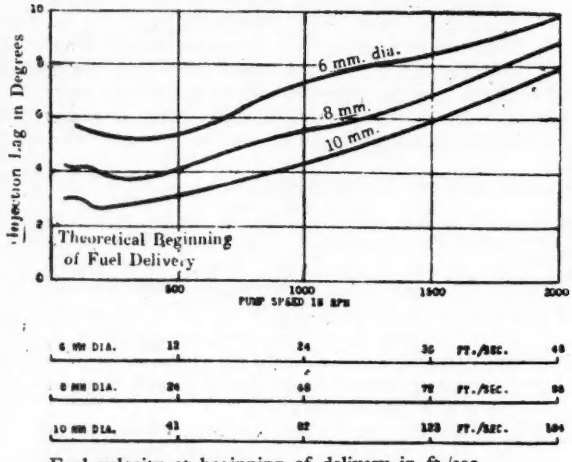
If an annular groove and two additional fuel ducts are added to the nozzle, the volume in the nozzle due to these is increased by 252 cu. mm.



Inside DIA. of discharge tubing in inches.
8 mm. DIA. plunger.
$\frac{1}{4}$" O.D. × 36" long discharge tubing.
1500 lbs./sq. in. nozzle opening pressure.
Discharge valve *without* retraction action.

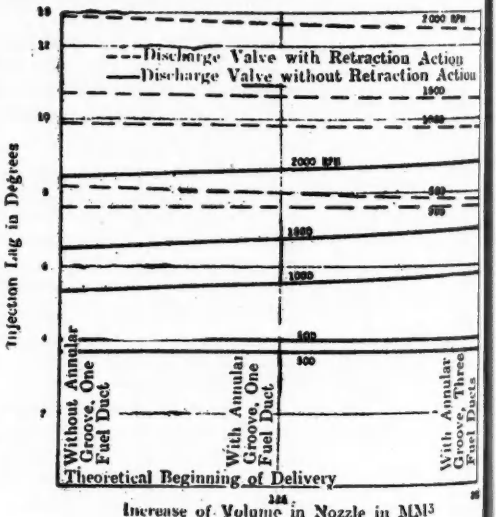
Fig. 7

Fig. 8 shows that with a discharge valve without unloading action the injection lag increases above 500 r.p.m. since, due to the increased volume, more fuel must be compressed from the



Fuel velocity at beginning of delivery in ft./sec.
$\frac{1}{4}$" O.D. × $\frac{3}{32}$" I.D. × 36" long discharge tubing.
1500 lbs./sq. in. nozzle opening pressure.
Discharge valve without retraction action.

Fig. 6


Discharge Valve with Retraction Action
Discharge Valve without Retraction Action
Injection Lag in Degrees
Without Annular Groove, One Fuel Duct
With Annular Groove, One Fuel Duct
With Annular Groove, Three Fuel Ducts
Theoretical Beginning of Delivery
Increase of Volume in Nozzle in MM3

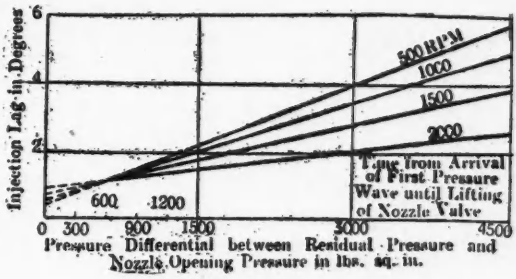
8 mm. DIA. plunger.
$\frac{1}{4}$" O.D. × $\frac{3}{32}$" I.D. × 36" long discharge tubing.
1500 lbs./sq. in. nozzle opening pressure.

Fig. 8

residual pressure which requires a longer period of time. Just the opposite is the effect on the injection lag when a discharge valve with unloading action is used. Here, too, more fuel must be compressed to the nozzle release pressure; however, during the closing of the nozzle valve at the end of injection a certain portion of the fuel column is not affected to such a high degree by the retraction wave, therefore the pressure in the piping drops less and the first pressure wave during the following delivery stroke travels faster.

4. **Effect of the Residual Pressure.**

Fig. 9 shows that the pressure rise after arrival of the first pressure wave at the nozzle valve takes place in varying periods of time if the difference between closing pressure and nozzle release pressure varies. Here the abscissa was chosen for the arrival of the first pressure wave at the nozzle valve. The vertical distance between the abscissa and the beginning of injection corresponds to portion (b) of the injection lag (see Fig. 2). This portion of the injection lag increases with an increase in the pressure differential and with a decrease in the fuel velocity at the beginning of the fuel delivery. From Fig. 9 it may be seen that at 3000 lb./sq. in. difference between residual pressure and nozzle release pressure, the time interval is considerably less than twice that for 1500 lb./sq. in. until the beginning of the lift of the nozzle valve, because the inertia of the nozzle valve must be overcome



8 mm. DIA. plunger.
$\frac{1}{4}$″ O.D. × $\frac{5}{32}$″ I. D. discharge tubing.

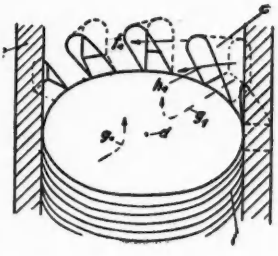
Fig 9

after reaching the nozzle release pressure. Thus, the curves do not go through the zero point if they are extended, although the pressure difference would be zero.

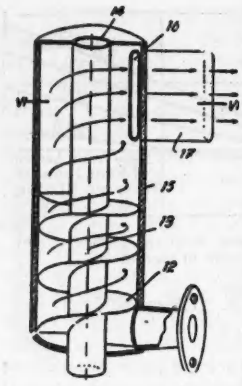
The residual pressure and, with it, the pressure differential, not only varies with the nozzle release pressure and the pressure piping flow area, but also with the discharge velocity of the fuel from the nozzle, which in turn depends upon the nozzle orifice area and speed. If the maximum nozzle opening area is changed the injection lag may vary somewhat due to the different residual pressure. However, the trend of the curves remains the same. The type of nozzle has no effect on the residual pressure but merely decides maximum nozzle opening area.

PATENTS AND INVENTIONS

INTERNAL COMBUSTION ENGINE. (By FRANZ ZAHREN, Brunswick, Germany). An internal combustion engine, especially a high-speed two-stroke internal combustion engine provided with direct current scavenging and inlet slots controlled by the working piston and distributed over the periphery of the cylinder in the same zone, in which engine the angle between the side faces of each slot and the tangent to the cylinder gradually varies from a value of less than 90 degrees to a total amount of about 90 degrees, and the angle between the upper faces of the slots and the axis of the cylinder differs from the angle between the lower faces of the slot and the axis of the cylinder.

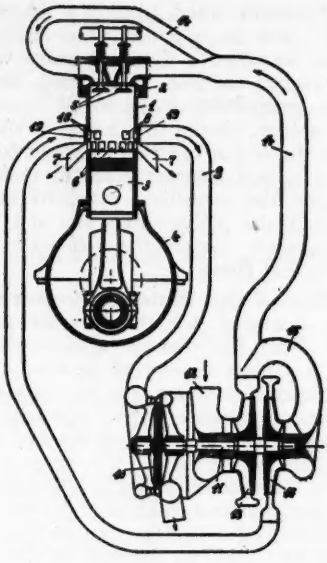


EXHAUST OF GASES FROM ENGINES. (By HENRI COANDA, Clichy, France). In an internal combustion engine, the combination of exhaust means, having an opening of conventional cross section, at least one tube element directly connected with said exhaust means, said tube having a similar conventional cross section at its connection to said exhaust means, and being gradually altered in form so as to be flattened and turned over upon itself in the form of a twisted band at the point where the gaseous sheet rotating about itself assumes in its portion flowing at



high velocity and high pressure, a flattened or ribbon shape, said point being spaced a short distance exteriorly of said exhaust means, a tubular conduit of flat section directly prolonging said tube element and helically wound so as to accommodate and accentuate the gyratory motion of said gaseous sheet, whereby the latter undergoes a high centrifugal action, and outlet means for said tubular conduit extending tangentially thereto in a direction at right angles to the axis about which said conduit is helically wound.

INTERNAL COMBUSTION ENGINE. (By ALEXANDER GARVE and OSKAR KURTZ, Augsburg, Germany). A two-cycle internal combustion engine having a number of working cylinders disposed in a multiplicity of rows laterally spaced apart, pistons operable in said cylinders, said cylinders having exhaust ports adjacent one end of the cylinders and arranged to be covered and uncovered by the pistons; scavenging air inlet openings at the other end of the cylinders, said cylinders also having additional openings for supplying supercharging air to the cylinders and arranged to be covered and uncovered by the pistons; a turbine driven blower for separately



supplying relatively low pressure scavenging air and relatively high pressure supercharging air respectively to the scavenging air inlet openings and the additional supercharging air openings; exhaust pipings leading from the said exhaust ports to the turbine and arranged on the outer sides of each of the rows of cylinders, and independent air pipings disposed one outwardly of the other between the rows of cylinders and extending from the blower to the scavenging air inlet openings and the supercharging air inlet openings.

BEHAVIOUR OF CRANKSHAFT CASTING MATERIALS UNDER FATIGUE STRESSING IN BENDING AND TORSION

By H. CORNELIUS. (From *Giesserei*, Vol. 27, Dec. 13th, 1940, pp. 491-499).

THE suitability of casting materials for crankshafts is best evaluated by notch sensitivity. This is considered to be more important than bending or torsion fatigue strength. The materials investigated for torsion fatigue under 3000 load reversal per min., with and without notch, were malleable iron, alloy gray iron, high carbon steel and rolled steel.

The first two of these showed high bending fatigue strength of notched specimens in relation to their tensile strength. Transversely drilled samples of high strength castings also had high torsion fatigue strength in relation to tensile strength, and this is considered to be due to the high ratio of torsion fatigue strength to tensile strength of smooth specimens.

The fatigue strengths of high-grade hardenable steels are not reached by the cast irons, because of the high tensile strength obtainable by hardening the steels. Soft iron has a high ratio of bending fatigue strength to tensile strength and a lower notch-sensitivity in fatigue bending.